The WHAT'S NEW magazine

JUNE 1984 $1.75

Popular science

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Highlights of this issue

74
New planes that will revolutionize aviation

Daring designs are winging their way into today's business planes—and tomorrow's jets.

83
Ion engines for our mission to Neptune

How do you propel a spacecraft on a 20-year mission where solar cells can't provide power?

56
New digital receivers deliver ultimate TV

Freeze-frame, zoom, paint-a-picture—these are just some of the amazing features of digital TV.

116
World's first electronic table and radial saws

How precise, convenient, and rugged are these unique tools? Our exclusive test finds out.

Cover photo from TRW Inc.

The What's New Digest 92–99

Science and Technology
Science newsfront 11
Permafrost hothouse 68
The coming age of micromachines 87
What's new—products and technology 92

Computers and Electronics
New digital receivers deliver ultimate TV 56
Electronic magic: new color for old b&w movies 78
What's new in electronics 98
Computerized paintbox speeds electronic art 102
Video trickery shrinks camera-recorder combo 122
Computer review: the expandable Acorn 125
Bits & bytes 140

Space and Aviation
Hot new planes that will revolutionize aviation 74
Ion engines for our mission to Neptune 83

Energy News
Knockdown turbine for remote sites 52
World oil supply: from famine to glut 54

Cars and Driving
Detroit report 18
Car test: Detroit vs. Europe—luxury sports coupes ... 34
BMW's 3-series grows up 48
Alfa Romeo's Japanese connection 66
Rapid rotary has tuned induction 67
PS exclusive: first look at Detroit's '85 models 80
What's new for your car 99
PS 3,000-mile test: Plymouth's compact van 105

Recreation
Through the viewfinder 28
What's new in boating 95
Safer gaff 145

Home, Shop, and Yard

Products
New washer's an efficiency champ 64
What's new in home improvement 97
Invisible hinge you glue in place 112
Thermal shutters lock out heat (and intruders) 113

Plans and Projects
Leisure homes: two designs linked to their sites 100
Patio deck with butcher-block built-ins 106
Make a butcher-block patio stool 109
Pave a patio with ceramic tile 110
Nesting dinghy you can build 114

Home Energy Management
Alternate-energy answers 24
Superinsulation wall system 144

Tools and Techniques
What's new in tools 96
World's first electronic table and radial saws 116
Your electric ovens—how to keep 'em all cooking 126
Housepower clinic 134
Super saw blades—which cuts smoothest? 137
Electronic tape measure 138
Shop talk 146

Car care
"Say, Smokey—" 50
Beginner's guide to auto repainting 119
Taking care of your car 150

Additional Features
Readers talk back 4
What's news 73
Wordless workshop 152
Product information 168

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The new generation 1984 Toyota trucks are turning the truck world upside down, because they're the most advanced trucks ever built. But if one truck had to do it all by itself, this would be the one.



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Readers Talk Back

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Einstein's sail

C. P. Gilmore's article, "Spin Sail: Magnus Effect Powers Ships" [Jan.], reviews the history of the Magnus effect and the Flettner rotor. Your readers may be interested to know that Albert Einstein had an interest in both, and in fact wrote an article on the effect. The article appears in an English translation of Einstein's "The World as I See It." Einstein was very much interested in the work of the German physicist Prandtl, and it was probably through Prandtl's work that he came to know of the Flettner ship.

Einstein writes:

"Magnus confirmed his explanation by experiments with a rotating cylinder which was not materially different from a Flettner cylinder. A little later the great English physicist, Lord Rayleigh, independently discovered the same phenomenon again in regard to tennis balls and also gave the correct explanation. Quite a short time ago the well-known professor Prandtl made an accurate experimental and theoretical study of fluid motion around Magnus cylinders, in the course of which he devised and carried out practically the whole of Flettner's invention. It was seeing Prandtl's experiments that put the idea into Flettner's head that this device might be used to take the place of sails."

Martin Tamny, Closter, N.J.

Counterfeit images

I'm a computer engineer familiar with image processing and its applications, such as the Scitex system you have described ["The Magic Picture Machine," Nov. '83, and "What's News," Dec. '83 and Jan. '84]. I can assure Jerry G. Taylor that his concerns [that the machines might be used to create spurious pictures, "RTB," March] are unfounded. First, all digital images stored in a computer system are in picture-element, or "pixel," form. When displayed on a graphics-display terminal or printed on paper these pixels appear as spots that, when viewed from a distance, appear to converge into a continuous picture. But when examined closely, the individual pixels can be readily discerned. A photograph taken with a camera is not made up of pixels and therefore is a continuous image. If a photograph of an image produced on the Scitex system (or on any other computer-graphics system) were created, the pixels would still be visible when magnified. Therefore the authenticity of a picture or photograph may be readily verified.

Louis S. Leopold, Peabody, Mass.

World power

If even only a tiny percentage of the immense energy of Earth's rotation could be efficiently harnessed, like a revolving electric-generator rotor, through cables looped north and south around the world, perhaps the necessary cooperation of the world's major powers would enhance our prospects for peace and provide unlimited electrical energy to those who need it most.

In the January 14, 1982, issue of *Nature*, S. I. Akasofu, of the University of Alaska's Geophysical Institute, reported that significant amounts of electric current have been induced in utility transmission lines by the auroral electrojet, a concentrated current in the ionosphere.

J. V. Evans, chairman of the Committee on Solar-Terrestrial Research of the National Academy of Sciences, wrote in the April 30, 1982, issue of *Science*: "Large electric fields are generated and sustained a few thousand kilometers above Earth's poles."

And in the September 1983 issue of *Scientific American*, Raymond Jeanloz discussed evidence indicating that a turbulent flow of liquid-iron alloy around Earth's core is generating Earth's magnetic field.

It seems as though we ought to be able to use our existing Earth cabling and microwave technology and/or our existing space-station technology to string out paths that would somehow intercept some of the inductive electrical energy in which our planet is apparently awash.

Paul Hengstenberg, W. Hartford, Conn.

Super-scan

Your article "Giant Scanner Inspects Rocket Motors" [March] is informative but fails to show the larger context of this work. How can you use the phrase "optimal performance and safety" to

Continued

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Popular Science

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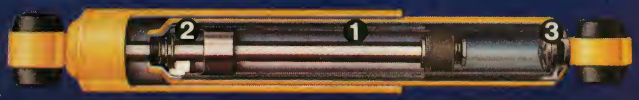
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Readers Talk Back

describe a system that, if it were to fulfill its mission, would kill countless millions of people and irreversibly damage the environment? A single Trident II submarine carries hundreds of nuclear warheads totaling seven times the explosive power of all the weapons used in World War II. The high accuracy of these warheads implies that they are first-strike weapons capable of destroying the U.S.S.R.'s "deterrent" force and hence persuading the U.S.S.R. to adopt a "launch-on-warning" policy. How can we afford to euphemize these instruments of death when the destruction of everything we know and care about is only a hair-trigger away?

James T. Hoffman, Amherst, Mass.

Balky Fiero

As the owner of a 1984 Fiero SE, I must concur with Jack Keebler's statement ["Pontiac Fiero SE," Feb.] on the potentially dangerous malfunction of the sticking accelerator.

I have, on five occasions since December 1983, encountered this situation, three times on start-up of the car and twice during highway driving. Also, the idling rpm is 2,000 to 3,000 rather than 1,000 to 1,500. The fuel economy has dropped significantly: from 26 to 30 mpg down to 14 to 16 mpg.

It's been five weeks since my car was examined by the dealership and the idle sensor placed on order. I am repeatedly told that "they are on back order." If that is the case, I hope the design of the sensor is being changed in order to correct this problem.

I hope General Motors will immediately correct this hazard. I want to add, however, that other than this serious problem, I love my car!

Janelle Eads, Waynesboro, Va.

A question of leisure

What is a leisure home? So far as I can tell, the "leisure homes" you feature would be perfectly acceptable houses for year-round living. Take April's three-bedroom, two-bath model, for example. The only difference between it and a regular house is the lack of a conventional gas- or oil-fired heating system. (Presumably the solar features, the circulating fireplace, and the heavy insulation accomplish the same purpose.)

What's the distinction between a regular house and a leisure home?

G. R. Paterson, Evanston, Ill.

Al Lees replies: "Sometimes, as with the April house, it's only a matter of style. There's a casual feel to this home, both indoors and out, that reflects the fact that the architect designed it specifically as a second home: the rather rustic lack of architectural detailing, for example, and the open floor plan. Still, the house has all the basic amenities and could be built within most suburban communities and small towns.

"There are two basic schools of thought regarding leisure homes. One feels that they should be compact, basic houses, preferably of unconventional design, that make for low-maintenance weekend use yet can be adapted as retirement residences—just large enough for a couple. That happens to be my own view and the philosophy behind the PS Lockbox House (subject of a series of articles from 1974 through '75). The other school argues that vacation homes are for entertaining, so they need extra bedrooms (or at least sleeping facilities) for putting up guests. This school feels that even when the owners are empty-nesters, the very fact that they have a home in a vacation area will draw their kids back (with their families) for visits, so those extra bedrooms will always be needed."

Mac attack

I want to take issue with the article about the Macintosh personal computer ["Apple's Mighty Mini Mac: Can Little Mac Challenge Big Blue?" March]. The computer is described as a 32-bit design when in fact the Motorola 68000 microprocessor used in the machine has a data bus 16 bits wide.

Granted, the internal architecture is 32 bits, but the computer should not be considered that unless the entire design, including the data bus, is of the same bit width. I believe any description to the contrary is misleading.

Damon Hill, Atlanta, Ga.

Kathleen Travers of Apple's customer-relations department says: "The Macintosh is not a true 32-bit machine. The address bus is 32 bits and the communications bus is 16 bits. Apple emphasizes the 32-bit internal architecture in its marketing just as IBM does when it calls its PC a 16-bit machine—it's really only an eight-bit machine."

Corrections: The Nomad 800 telephone from AT&T ["Cordless Phones," April] does not use a 49-49-MHz multiplexed system as stated. It operates in the 1.7-MHz range.

The Acutemp thermostat ["What's New in Home Improvement," March] is available only with the company's tankless water heater. PS

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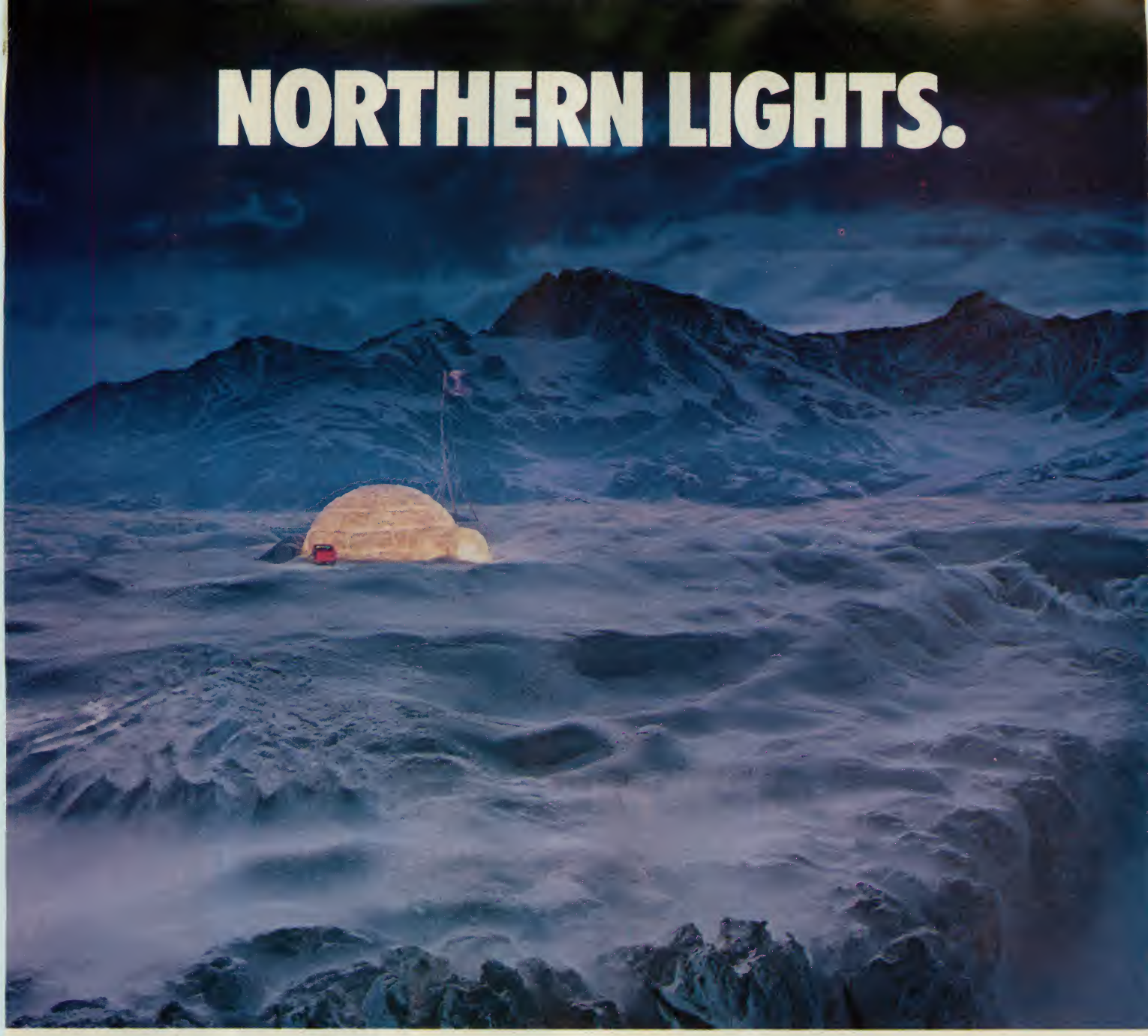
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Science Newsfront

By ARTHUR FISHER



Space-station concept

When President Reagan last January directed NASA to develop a manned space station within the next decade, he set in motion a program that had been long poised for takeoff; many individuals, government agencies, and aerospace companies have been working on plans for such a station for years. One of eight space contractors that had recently completed a study for NASA on possible space-station requirements, for example, is Lockheed Missiles & Space Co., whose ideas are embodied in the artist's concept shown above.

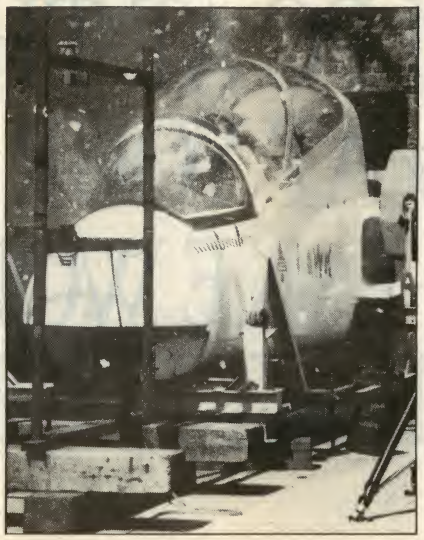
In this version, station control and operations would be conducted in the central vertical module. This module, with solar panels, thermal radiators, and communications equipment attached, would be the first to be placed in orbit via the space shuttle. More shuttle flights would add the four main modules, truss-structure docks, connecting passages, and payloads.

According to Bill Wright, Lockheed's vice-president for NASA programs, here are some of the potential uses of a space station: manufacturing; satellite repair and replacement; scientific research; and observation of Earth resources and weather patterns. The station could also serve as an intermediate launching platform for higher-altitude satellite missions.

Bird-proof cockpit

Every pilot has a nightmare about flying head-on into a bird at high speed. Collisions with birds, especially large ones, have caused fatal crashes when the windshield was smashed.

The dramatic photo below shows the success of a new windshield material in averting cockpit penetration. The



test, photographed at the moment of impact, was designed to simulate the collision of a bird with a jet plane and was actually carried out at a speed of 610 mph. Witnessed by experts from Britain's Royal Aircraft Establishment and engineers from British Aerospace, the test proved that the new material increases the pilot's protection by stretching up to five inches on impact and then returning to its original shape.

The windshield material is laminated; it consists of a transparent polycarbonate core sandwiched between outer acrylic layers. A high-speed impact produces cracks in the outer acrylic layer, but the shield is not punctured, and the pilot can see well enough to make a safe landing. The new material is manufactured by Britain's Lucas Aerospace, which already makes windshields for many European-built civilian and military aircraft. The danger of bird impacts is increasing, particularly for military jet aircraft, which fly at ever-higher speeds at low altitudes.

Long-lived (!) quark

Particle physicists in the United States and Italy have for the first time measured the lifetime of the so-called "bottom," or "b," quark, a member of the gaggle of elusive particles that are thought to be the basic building blocks of all matter. The result came as a surprise because, according to Dr. Donald E. Groom of the University of Utah, "By our standards that's an extremely stable particle and a long lifetime. It's four or five times longer than anyone might have expected."

That "long lifetime," measured primarily at the Stanford Linear Accelerator in California: an estimated 1.5 picoseconds (trillionths of a second), or about the time it takes light to travel one foot!

Blue genes for blue jeans?

Microbiologists at the University of Texas at Austin have used genetic-engineering techniques to prod bacteria to produce indigo, the dye that gives blue jeans their characteristic hue. Once extracted from plants (or, by the Romans, as Tyrian purple from certain snails), indigo is now chemically synthesized by a patented process and costs about $10 a pound. The bioengineered indigo is not yet competitive economically because it requires a chemical—indole—that is even more expensive than commercial indigo. But Dr. David Gibson and Larry Wackett, both of the University of

Continued



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Built-in picture instructions can help the first-time user get started.

Diskette-drive systems include a program that allows users to explore computer fundamentals at their own pace. And to get PC*jr* up and running from the very first day, a sample diskette with eleven useful mini-programs is also included.

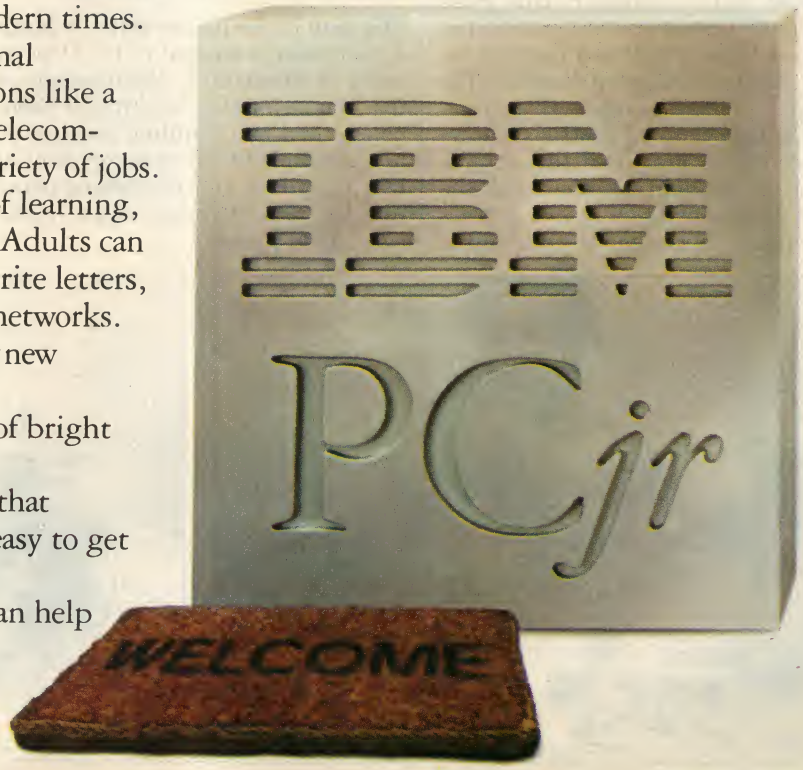


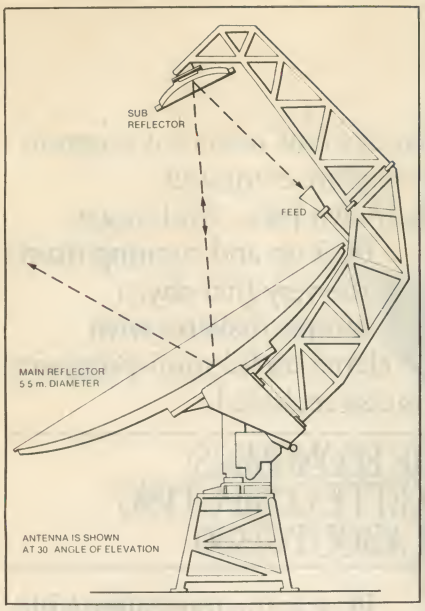
HOME ECONOMICS: IBM DISKETTE COMPUTING FOR ABOUT $1300

PC*jr* is the most affordable of the IBM personal computers.

A diskette-drive model with a 128KB user memory is about $1300. An expandable 64KB cassette/cartridge model is about $700. (Prices apply at IBM Product Centers. Prices may vary at other stores.)

For a demonstration, visit an authorized IBM PC*jr* dealer or an IBM Product Center. And you can find the store nearest you with your little finger. Just dial 1-800-IBM-PCJR. In Alaska and Hawaii, 1-800-447-0890.







Texas, and executives of Amgen, a California-based genetic-engineering-research firm that is funding some of the research, believe that the knowledge gained from these experiments could eventually lead to important new products from bioengineering.

Smaller satellite antenna

A new British antenna based on a 300-year-old design promises to ease rooftop installations for commercial concerns communicating with geostationary satellites. Produced by British Telecom, the dish, shown in the diagram and photo above, has an offset feed and subreflector. This gives the parabolic antenna a narrower microwave-beam width and permits using a dish only 18 feet in diameter. The design is called an offset Gregorian, after a 17th-century Scottish mathematician who first used this geometry for an optical telescope. With the beam width narrowed to two degrees as opposed to the more-usual three degrees, there are more orbital "slots," providing an extra 60 possible locations around the world.

The rig has a dogleg lattice-steel tower rising 13 feet above the dish supporting the feed horn and subreflector. Such an array allows using a shallower main reflector, giving more-precise beam convergence.

The dish has been installed by British Telecom on a building in London and will be used to launch SatStream North America, the world's first end-to-end, satellite-based digital-transmission service across the Atlantic.

Why is this man smiling?

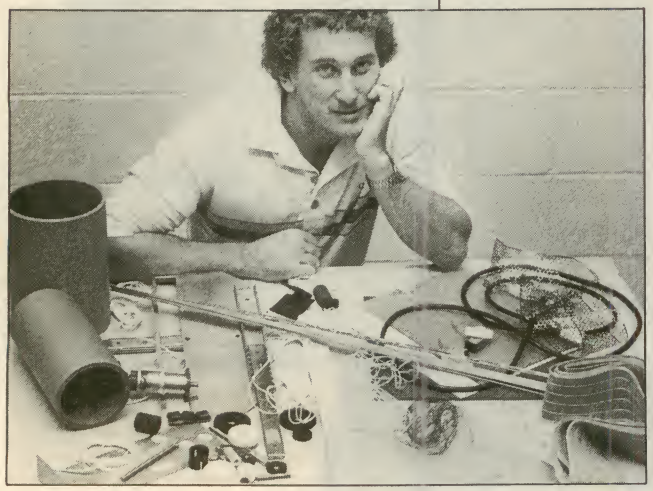
The man in the photos below is Mark J. Schlueter, a student in the Department of Mechanical Engineering at the Massachusetts Institute of Technology, and he is smiling because he has assembled the odd assortment of bits and pieces in the left-hand photo into the prize-winning device in the right-hand photo.

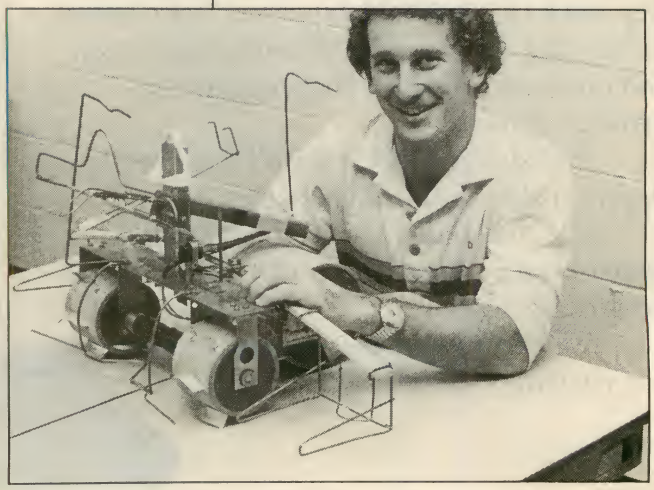
The design competition he won is a major segment of the department's Introduction to Design course. Each year students are given identical kits of parts from which they must assemble a machine capable of performing a given task. The assignment for this contest was dubbed "Pacthing" because the machines had to be controlled by joy sticks like those used in video games such as Pac-Man. The object: Five tennis balls were placed in each half of a rectangular table filled with a bed of sand. Students manipulated their machines while facing one another from either end of the table. The winner of each heat was the machine that had moved more of its tennis balls to the opponent's half of the table during the 30 seconds allotted. A single-elimination tournament decided the winner.

In the photo at left Schlueter is contemplating, somewhat ruefully, the kit of parts every student received. Included were three motors, springs, cardboard tubes, welding rod, string, plastic gears, webbing, fiberboard, and pieces of wood.

The next photo shows the machine that Schlueter assembled after weeks of frustration. The cardboard tubes have become wheels with bent metal cleats that dig into the sand. The bits of wood and some welding rod have turned into arms that snap out from the sides of the machine. These arms can move three or more balls at a time, allowing the whole device to move in a straight line. Schlueter also added a fiendish complication—a projectile that was launched from his own machine into enemy territory, where it posed a navigational hazard to his opponents' creations.

The devilish designer of this competition is Professor Woodie C. Flowers of MIT's Department of Mechanical Engineering, who is also coordinator of the design course. PS







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The Whistler® Spectrum™. It was chosen #1 by *Motor Trend*, "The Whistler Spectrum resides at the top of the list. A world class radar detector." *Autoweek Magazine* says, "The Spectrum is the most sensitive radar detector Autoweek has ever seen." Plus, nearly one out of two truckers who own radar detectors own Whistler. And there's only one reason.

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Sensitive receivers also detect microwave intrusion alarms, which are particularly frequent and annoying in urban areas. Spectrum's exclusive Filter Mode allows you to operate at full sensitivity at all times, even in the city. Because the Filter Mode simply changes the way the Spectrum alerts you when intrusion alarms are present.

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The Radial Mud-Terrain T/A is built strong and rugged to maximize truck dependability—off the road or around town. Its tread has self-cleaning grooves for remarkable traction in deep mud or snow.

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The BFGoodrich Radial Mud-Terrain T/A is available in sizes for direct application on most original equipment wheels:

A. Three carcass plies help resist sidewall bruising to optimize truck dependability.

B. Tread pitch sequencing offers quiet ride.

C. Deep self-cleaning grooves provide excellent traction.

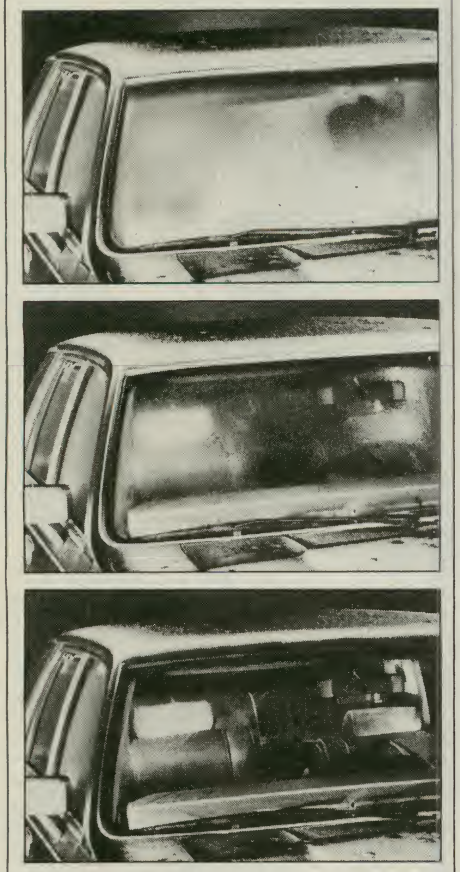
D. Dual compound tread imparts outstanding mileage.

The Radial Mud-Terrain T/A® was designed specifically for outstanding truck performance. In fact, professional drivers recently tested the Radial Mud-Terrain T/A on a specially modified off-road truck. The result: outstanding rugged performance. When equipped with the Radial Mud-Terrain T/A, the test vehicle demonstrated remarkable traction capabilities. Even through mud bogs with the viscosity of wet cement under two feet of water.

WE MAKE TRUCKS PERFORM

Detroit Report

By JIM DUNNE



No more defrosters

The windshield's warm-air defrosters may be going the way of the running board. That's if an all-electric idea called Quick Clear from Donnelly Mirrors of Holland, Mich., wins wide acceptance. The Donnelly windshield (above) has a thin coating that acts as an electrical conductor. It heats up and clears off fog—and even ice.

"We can clear 1/10 inch of ice at minus 10 degrees F in four minutes with Quick Clear," says Mike Buford, program manager for heated glass products at Donnelly. "For today's defroster it would take 18 to 23 minutes to do the same job, even at warmer ambient temperatures." Quick Clear works on the whole glass surface at once. The key to the system is an iridium-tin oxide coating on the inside of the outer pane of windshield glass. Electrical buses at each end of the glass furnish the heating power to the coating, which acts as a resistor, just like the lined defoggers on rear windows. A standard alternator provides the necessary voltage. While the windshield is being defrosted, the alternator feeds power only to the defroster. The other car systems run on battery power. Once the defroster timer shuts down —after four minutes or so—the alternator resumes its charge to the battery.

Buford reckons that Quick Clear will be used by most luxury cars within a couple of years. But its $300 extra cost will keep it out of low-price models except as an option. Eventually, predicts Buford, a car's instrument panel may be redesigned to eliminate the defroster slots as the Quick Clear system takes over.

The idea of heated windshield coatings is not new. Ford offered a gold-film type on Thunderbirds and Lincolns in the mid-1970s for two years. (Donnelly's coating imparts a purple tint.) But the $700 to $800 extra cost and the complication of a second alternator made the Ford system impractical.

Under the gun

It's just in time or not at all. That's the problem with the new system of car assembly in Detroit, in which supplies are brought to the assembly line just in time for use, thus cutting down on expensive inventory buildup. It has already caused a line shutdown. General Motors' C-cars (de Villes, 98s, and Electras) are being built under this setup, but when one supplier delivered poor-quality window frames for the de Villes, the devil chain that runs the assembly line was stopped until better-quality frames could be delivered. Under the old system, a large inventory of window frames could have been tapped to fill the void. GM executives think this is just a start-up glitch; once parts suppliers get the quality word, they say, line shutdowns won't occur.

Olds four-valve four?

It's a new type of four-cylinder engine that relies on multiple valves for more power. Details are a secret, but the displacement has been pegged at 2.3 liters (140 cu. in.). There are also rumors that it will be used in most of the Oldsmobile models, perhaps even in the new 98. Output should be about equal to that of many V6s. Olds got the go-ahead from General Motors management to continue development and to prepare to build the engine for 1986. It will be a GM first—a high-speed, high-output four-cylinder engine with four free-breathing valves per cylinder.

Hotter Escort

That's the scenario for 1985, when the first "freshening" of the Ford Escort hits the streets. A new 1.9-liter (116-cu.-in.) engine is planned to replace the present 1.6-liter (98-cu.-in.) four. It may not sound like a big increase, but that 0.3 liter is an 18-percent increase in displacement. Acceleration should be markedly improved with zero-to-60-mph times in the 13-second class.

But fuel economy will at least remain the same, if not improve. How? An overdrive transmission that will take advantage of the stronger engine's increased output will be used. Styling will be updated, too. Among the refinements are a bustle-back profile, with the trunk separate from the passenger compartment, and aerodynamic headlamp covers.

'Vette with less

On tap for 1985 is a high-output version of the 305-cu.-in. V8 for the Corvette. This will replace the present 350 V8. The 305 will get multi-port fuel injection to make up for the loss in cubic inches. This should help it produce either equal or better power than the bigger engine. Why the shrinkage? General Motors wants to improve fuel economy and phase out the limited-production 350-cu.-in. gasoline engine.

Small-car air springs

As expected, Ford will expand the use of air springs to small cars. The innovative suspension system, introduced this year on the Lincoln Mark VII and Continental, is slated for a strut-suspension Ford later this year. Although the system reportedly costs more to manufacture than conventional steel springs, it produces a better ride. Later it will offer the capability of raising or lowering the car's body for increased aerodynamic efficiency. Air springs aren't planned for the aftermarket. The added complexity of the computer-controlled compressor makes a retrofit impractical. PS

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But only one can.

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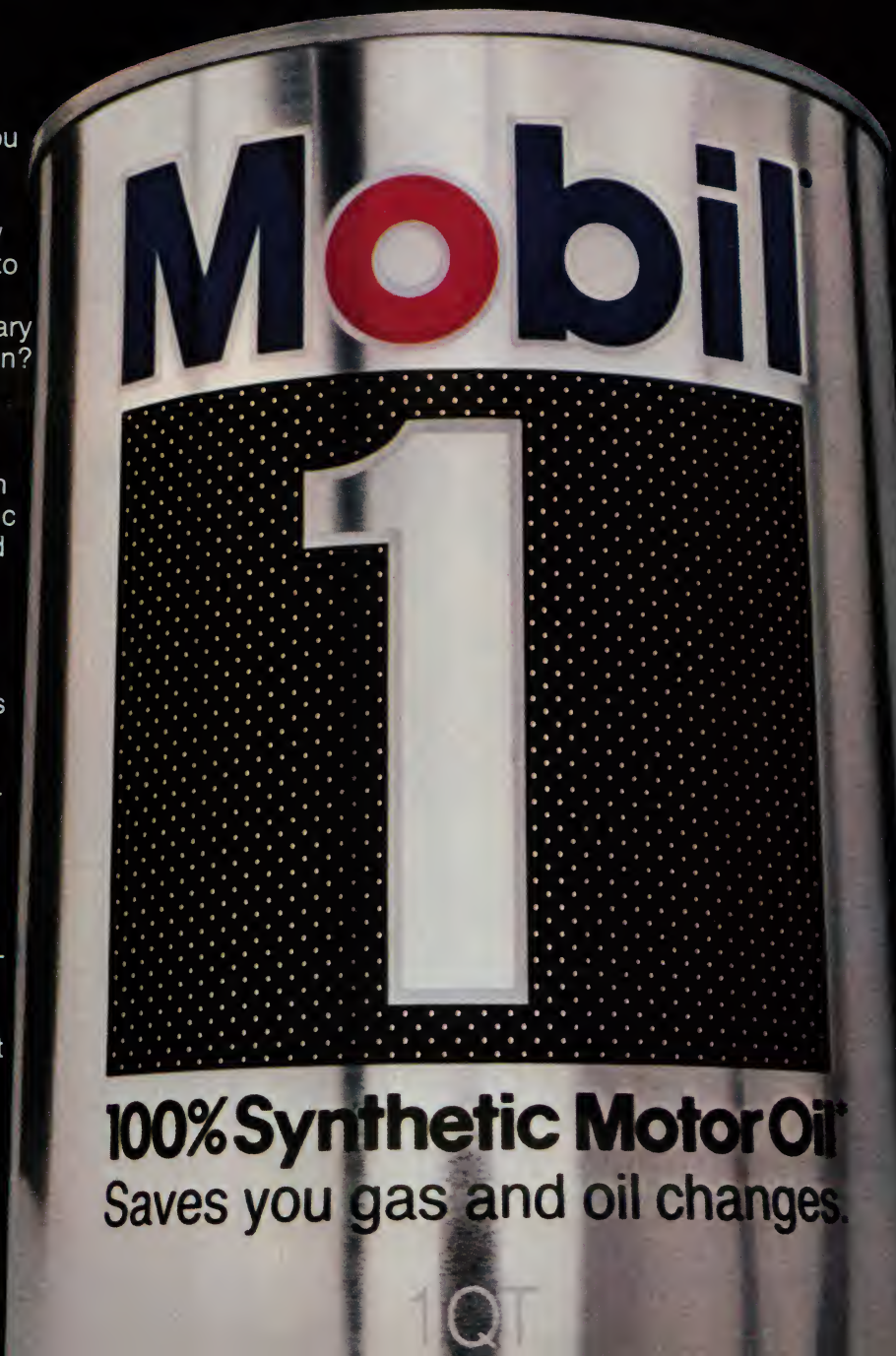
Mobil 1 gives you better lubrication than ordinary oils, helps protect your engine better from friction and wear and also helps it stay cleaner, run smoother and last longer.

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Besides protecting your engine a lot better, Mobil 1 also protects it a lot longer. Because it's the oil that can take you 25,000 miles or one year (whichever comes first) between oil changes.*

If protecting your engine is important to you, change to Mobil 1. You can't get better engine protection. And nobody can change that.

*Add oil as needed. New car owners follow warranty instructions. Diesel owners follow manufacturer's instructions.



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LIKE PORSCHE IS ONLY A CAR.
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Warning: The Surgeon General Has Determined
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Alternate-Energy Answers

By JAN F. KREIDER

Jan F. Kreider is a consulting engineer specializing in the design and economic analysis of solar-energy and energy-conservation systems. He is the author of several books on solar technology and a lecturer at the University of Colorado.

Fungus hazard?

Lots of POPULAR SCIENCE articles, including "Solar Attic" in the January '84 edition, describe pumping solar-heated air through an insulated-rock storage bed and then into the house as needed. My worry with this is condensation in the rock bed, resulting over time in mold or fungus growth and associated health and odor problems.

R. E. Fritsch, Columbus, Ind.

Solaron Corp., builder of thousands of air-and-rock solar systems for a decade, has never had this problem. The basic reason is that the rocks are hot, the winter air is dry, and no condensation occurs. With no moisture, there is no growth of these substances.

Recirculation and infiltration

Recently I talked with the manufacturer of a solar system that uses air collectors for space heating. This system obtains *all* of its input air from the outside, heats it in the collectors, and then pumps it into the house. The explanation for using the system was that the slight pressure this creates in the house completely prevents infiltration and results in a greater heat saving in average (not super-sealed) houses than one would get from recirculating systems.

James R. Thompson, Oakton, Va.

This reasoning is faulty. Because the sun shines less than 25 percent of the average day in Virginia at an intensity useful for heating, the building will be pressurized only 25 percent of the time in winter. Therefore, the effect on infiltration is not significant. It is best to use the standard recirculation solar system after *all possible sources of air leakage have been sealed.*

Stove upkeep

I bought a Concord woodburning stove with catalytic converter [PS, Jan. '82]. Can I use the stove after the converter burns out, or would creosote accumulate in the secondary chamber?

Stephen Szabo, Denver, Colo.

It's best to replace the converter. Inspection, proper service, and occasional replacement are wise, both for the reason you suggest and to maximize the heat produced during combustion.

Hot mobile home

I hope to reduce the running time of the air conditioner in my mobile home by installing a second roof of galvanized steel over the original one. There will be a five-inch air space between the two roofs, and the ends will be open so that air is free to flow.

B. M. Cikeer, Weslaco, Texas

Heat buildup in mobile homes results from inadequate roof vents, advises reader Paul Funderburg in reply to the July 1983 item "Cooling a Trailer." He adds that wind turbines can be highly successful in cooling the space between the roof and the ceiling.

Your proposed solution will work well to reduce heat gain through the roof. I would leave the second roof entirely open at the ends and sides to ensure the maximum possible airflow. Prime your galvanized roof with an etching primer, then topcoat with a white or other light paint.

Adding insulation

My two-story house is insulated with eight to 10 inches of loose fiberglass in the attic above the second floor. Is it better to install additional insulation on the underside of the roof with staples or just to lay additional blankets over the existing insulation on the floor of the attic?

Earl Mielke, Cockeysville, Md.

On a time, cost, and appearance basis, insulation should be installed on the attic floor. The insulating effect will be virtually identical in either case. However, if you buy batts with a vapor barrier, you'll need to slash it to avoid condensation in the middle of your double layer of insulation.

Solar tilt

My solar water-heating system has 120 square feet of panels placed flat on a 4/12 pitch roof. The pump circulates water from a 120-gallon storage tank. In summer, there is no problem: The sun hits the panels at close to a 90-degree angle, and I generally get at least a full tank of 160-degree-F water. But in winter, the sun hits the panels at a much lower angle, and the water temperature will not rise above about 110 degrees F. What do you suggest?

K. P. Warner
Huntington Beach, Calif.

Your collectors are positioned at too small a tilt angle relative to the horizontal. To improve performance, tilt them up to 30 or 35 degrees. If this is not possible aesthetically or architecturally, you could place reflectors at the top of the panels to direct winter sun's rays onto the collector. If the system is functioning properly, your ratio of 120 gallons/120 sq. ft. should produce ample hot water year-round.

Solar-heater dampers

I have an air-type solar heater consisting of seven panels without storage. At certain times of the day, one or more of the panels are in the shade, and I need a way to stop the airflow in these panels so that the fan only draws from the "hot" ones. This damping device should also prevent reverse siphoning at night or in cold weather.

W. C. Swift, Weston, Ont.

A simple and reliable way to do this would be to use motorized dampers controlled by a thermostat in the outlet airstream from each collector. If this temperature drops below 80 to 85 degrees F, the damper closes, forcing all airflow through the unshaded collectors. These dampers also close at night to avoid backflow. The dampers should be spring-loaded closed and powered open because they will be closed during the heating season for a longer time than they will be open.

You should consider using fewer than seven dampers because of cost. I'd recommend using only one damper to control the three most-frequently shaded collectors. Insert it in a duct into which the flow from these collectors is directed prior to entering the house. Then control the night backflow for the entire collector array with a standard, nonmotorized back-draft damper in the main return or supply duct for the full array.

Got a question on an alternate energy such as solar, wind, water, or wood? Wondering about energy-conservation techniques for home heating or cooling? Every other month, alternating with "Adventures in Alternate Energy," Jan Kreider answers selected questions from readers. Send yours to Energy Questions, POPULAR SCIENCE, 380 Madison Ave., New York, N.Y. 10017. Individual queries can't be answered by mail.

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A six-stage phosphate and acid treatment cleans and conditions the body for enhanced paint adhesion and corrosion resistance.

Extensive use of galvanized steel in critical areas makes Dodge steely tough on rust.

Front suspension crossmembers are protected by a special autophoretic cleansing process for increased corrosion resistance.

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Limited warranty covering outer body rust-thru on new '84 full-sized pickups and Ramchargers at no extra cost for five years or 100,000 miles, whichever comes first. Ask dealer for details.

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Use EPA est. mpg to compare. Your mileage may vary with speed, distance, weather. Actual hwy. mpg and CA ests. less.

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$699 Breakthrough
Sensory Blast

Treat your senses to the vibrant color of this slotted mask, black stripe, cable ready, 19" TV. Relax with the infrared TV remote control. Plus, let your senses feast on the sound of the TV and all your favorite records, cassettes and AM and FM stereo stations. This is a state of the art Audio/Video system. Wow!

Forget the $1499 suggested retail. And forget the $715 dealer cost.

DAK is buying truckloads of this state of the art Audio/Video entertainment system for cash. At just $699, you'll save big, but wait till you see all you'll get.

SOMETHING FOR EVERYONE

Just flip a switch. If you don't have cable, you can receive all VHF and UHF stations. But if you have cable, or if it's coming to your area, we've got it all.

And having it all, means the latest black stripe, slotted mask, brilliant picture, and all electronic direct access frequency synthesized color tuning. Plus, auto color, auto brightness, auto scan and much more. But, let's examine 'cable ready' first

Now you can tune in up to 36 cable channels from your easy chair. This new cable ready TV tunes all standard VHF channels 2-13, VHF Midband Channels 14-22, plus the VHF Super Band Channels 23 to 36.

Numerical equivalents of CATV channels (Conversion Table)

Channel			
A – 14	G – 20	M – 26	S – 32
B – 15	H – 21	N – 27	T – 33
C – 16	I – 22	O – 28	U – 34
D – 17	J – 23	P – 29	V – 35
E – 18	K – 24	Q – 30	W – 36
F – 19	L – 25	R – 31	

MOVIE CHANNELS

If there's a movie channel on your cable and it's not scrambled, this TV is all you need. If it's scrambled, you'll need the cable company's box.

Note: Check with your cable company before viewing anything at all, to see if they require you to pay a fee.

SPORTS PLUS

There are lots of 'Super Channels' broadcast on cable. Most of them are simply broadcast outside your normal TV's tuning range. But now, many of them can be yours. There are the All Sports and All Movie Channels. Plus, there's Cable News Network and much more.

INFRARED REMOTE CONTROL

Here's the best part. With most cable boxes you can't use your TV's remote control. But with a cable ready TV, you're in complete command, and you're in command from your favorite easy chair.

Just get your hands on the wireless infrared remote control and the world is yours. You'll have direct random access to all channels. So, for example, you can switch directly from channel 2 to channel 18 electronically.

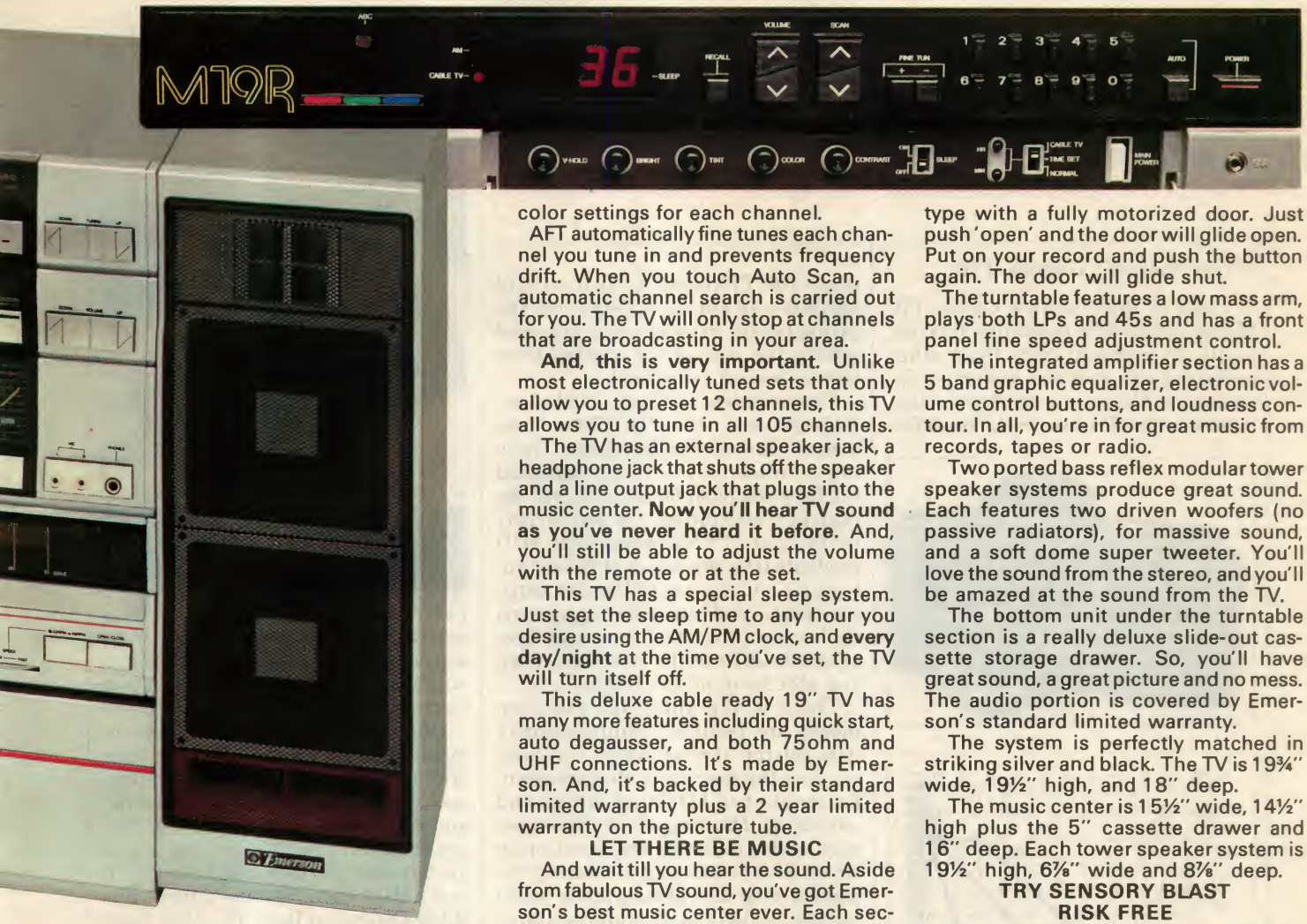


You'll see the channel you've chosen displayed on the TV's oversize LED display. And, if you push the 'Recall' button on the remote, the same display will show you the time of day.

After you've chosen the channel you want, you'll have total control of the volume. Plus, if the phone rings or a commercial comes on, you can even mute the sound with a single button.

But if you're like me, whenever a commercial comes on, I like to push the scan button and 'check out' what's on the





other channels. Of course, you can turn the TV on and off with the remote.

BUT IT'S THE PICTURE

Just like on the remote, you'll have full random access electronic frequency synthesized tuning. Electronic tuning means there are no mechanical tuners to wear out or cause snow. Frequency synthesized means this set will lock in and automatically fine tune.

You'll also have manual electronic fine tuning buttons so that you can take over.

But, look what this set will do for you. Auto brightness control adjusts the TV picture brightness to match your ambiant room light. An auto color switch lets the TV determine exactly the correct color settings for each channel.

AFT automatically fine tunes each channel you tune in and prevents frequency drift. When you touch Auto Scan, an automatic channel search is carried out for you. The TV will only stop at channels that are broadcasting in your area.

And, this is very important. Unlike most electronically tuned sets that only allow you to preset 12 channels, this TV allows you to tune in all 105 channels.

The TV has an external speaker jack, a headphone jack that shuts off the speaker and a line output jack that plugs into the music center. **Now you'll hear TV sound as you've never heard it before.** And, you'll still be able to adjust the volume with the remote or at the set.

This TV has a special sleep system. Just set the sleep time to any hour you desire using the AM/PM clock, and **every day/night** at the time you've set, the TV will turn itself off.

This deluxe cable ready 19" TV has many more features including quick start, auto degausser, and both 75ohm and UHF connections. It's made by Emerson. And, it's backed by their standard limited warranty plus a 2 year limited warranty on the picture tube.

LET THERE BE MUSIC

And wait till you hear the sound. Aside from fabulous TV sound, you've got Emerson's best music center ever. Each section is carefully designed to bring superb, dramatically pure sound to your home.

The cassette deck features a smooth-acting, auto-feather touch mechanism that will gently cherish your best tapes. You can record and play both normal and CrO^2 cassettes. And for whisper quiet recordings, there's Dolby B.

The AM and FM stereo tuners are really special. Tuning is totally automatic.

Just touch the up or down tuning buttons and the tuner will seek out the next station automatically. Or, switch to manual and check out each station if you wish.

You can select fast or slow scan, mono or stereo, and there are FM stereo and signal strength indicators.

The turntable is the latest front load type with a fully motorized door. Just push 'open' and the door will glide open. Put on your record and push the button again. The door will glide shut.

The turntable features a low mass arm, plays both LPs and 45s and has a front panel fine speed adjustment control.

The integrated amplifier section has a 5 band graphic equalizer, electronic volume control buttons, and loudness contour. In all, you're in for great music from records, tapes or radio.

Two ported bass reflex modular tower speaker systems produce great sound. Each features two driven woofers (no passive radiators), for massive sound, and a soft dome super tweeter. You'll love the sound from the stereo, and you'll be amazed at the sound from the TV.

The bottom unit under the turntable section is a really deluxe slide-out cassette storage drawer. So, you'll have great sound, a great picture and no mess. The audio portion is covered by Emerson's standard limited warranty.

The system is perfectly matched in striking silver and black. The TV is 19¾" wide, 19½" high, and 18" deep.

The music center is 15½" wide, 14½" high plus the 5" cassette drawer and 16" deep. Each tower speaker system is 19½" high, 6⅞" wide and 8⅞" deep.

TRY SENSORY BLAST RISK FREE

Tune in VHF, UHF or cable on the TV. Carefully inspect the picture for clarity, brilliance and vividness of color. The picture quality is simply breathtaking.

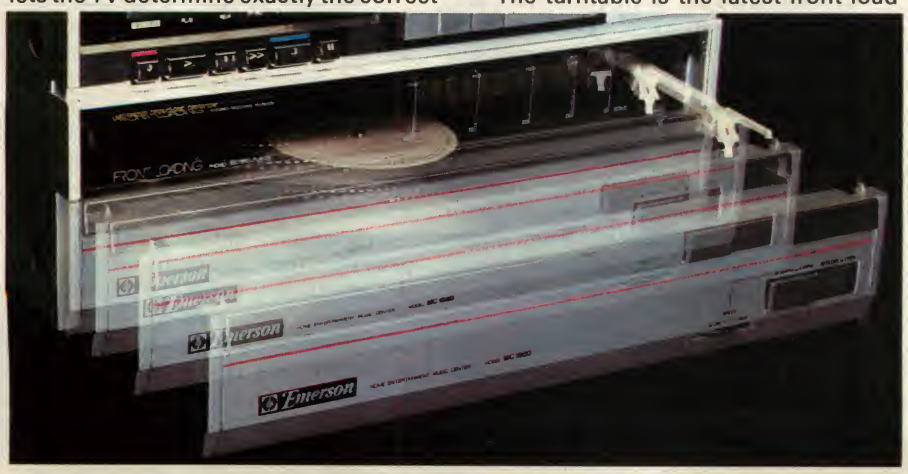
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This is an ideal main system for your home. And, at DAK's price, what a luxurious system for your bedroom. Wow! Try it all in your own home. If you're not 100% satisfied, return it in its original boxes within 30 days for a refund.

To order your Emerson Wireless Infrared Remote Control Cable Ready TV and Super Music System, don't send Emerson's $1499 suggested retail.

Don't even send their $715 dealer cost. Send DAK's truckload price of just **$699** plus **$65** for postage and handling. Order No 9814. CA res add sales tax.

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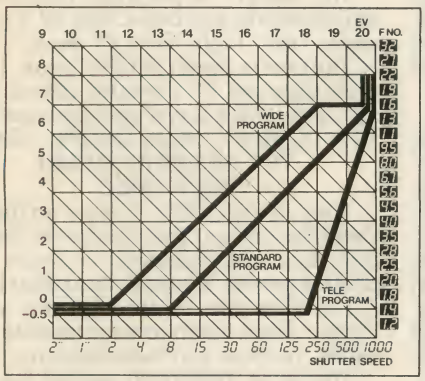
Through the Viewfinder

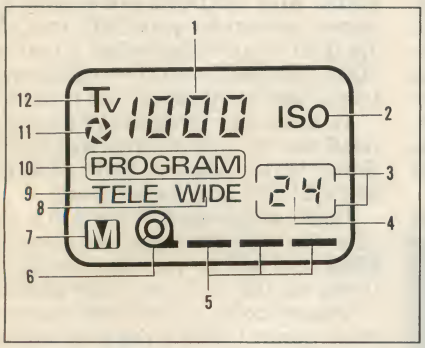
By EVERETT H. ORTNER

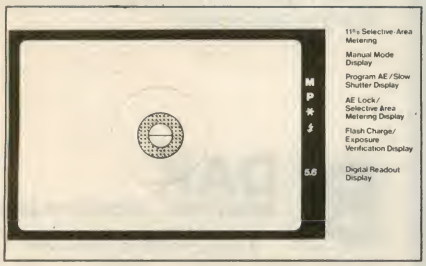
"New vision" Canon T70

It could be that the new Canon T70 SLR is too good for amateurs. It is certainly far removed from those other technological wonders designed for amateurs: the new squint-and-shoot autofocus 35s [PS, Dec. '83]. The difference: The T70 offers a complexity of controls—all automatic—that put the photographer in complete charge and reduce the role of the camera from that of master to servant.







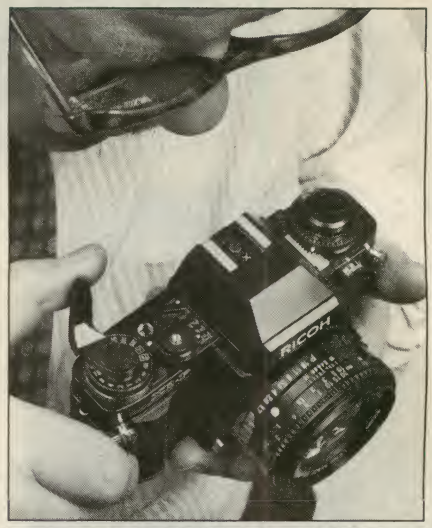


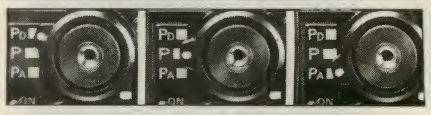
The president of Canon USA, Inc., Fujio Miterai, calls the T70 a "new vision." It's no exaggeration. There are no dials on the T70. Slides and microswitch push buttons control the camera's electronics. On top, a tiny (⅝-by-⅞-in.) TV-like screen with LCD readouts tells you which of the six automatic (or two nonautomatic) exposure modes and two metering patterns (full screen or central area) you have selected. LEDs in the viewfinder keep you abreast of other matters.

Three of the automatic-exposure modes are familiar: shutter-priority (you set the shutter speed; the camera sets the aperture); stopped-down, for certain non-FD Canon lenses; and auto-flash. The other three auto-exposure modes illustrate the direction in which SLR technology is heading: toward giving the photographer more control—along with automation—over all aspects of his picture.

These are programmed modes, each designed to emphasize a particular pictorial quality. You set the camera to WIDE if you want greater-than-usual depth of field, to TELE if you want a fast shutter speed to stop action, or to STANDARD for a middle path. The automatic programmed settings are shown at left center. The diagonal lines represent exposure values (EV); the numbers at right show aperture (f/number); shutter speeds are at the bottom. A typical EV of nine, for example, would produce settings of f/4.5 at 1/22 second in WIDE; f/3.5 at 1/40 in STANDARD; and f/1.6 at 1/200 in TELE. (Because both aperture and shutter speed are infinitely variable, the figures are my interpolated readings.)

The diagram of the LCD screen at lower left shows most of the readouts that would appear at one time or another—you would never see them all together in actuality. They show: 1 and 2, ISO (ASA) film speed; 3 and 4, frame area and frame number; 5, battery check, film-transport indicator, time-exposure timer; 6, film-load and rewind check; 7, manual mode; 8, WIDE program; 9, TELE program; 10, STANDARD program; 11, stopped-down auto exposure; 12, shutter-priority auto exposure. In case there's anything you still don't know, viewfinder symbols (bottom left) fill you in.





Other features of the T70: built-in motor (there's no film-advance lever and, of course, no need for an extra-cost winder), automatic film loading, and auto rewind. List price: $450. Also available with the T70 are a new programmed 277T electronic flash ($120) and a data back ($150)—Canon calls it the Command Back 70—that is capable of an astounding number of recording and control functions.

14-mode Ricoh XR-P

"User control" is the central concept of the new Ricoh XR-P, an SLR that offers a programmed three-option automatic-exposure system similar to the Canon T70's. You set the Ricoh's program dial (photos above) to one of three settings: Pd for automatic exposure with maximum depth of field, P for normal exposure, Pa for action-stopping fast shutter speed.

A feature unique to the XR-P is a TV mode. With lens and program dial set on P for program, you set the shutter-speed dial on TV—and behold, the camera is set to capture a picture on your TV set. More: By switching the program dial you can adjust the setting for European or computer-CRT scanning rates. The XR-P also offers match-needle manual control, aperture-priority automatic exposure (you set the aperture; the camera sets the shutter speed), and shutter-bias automation. The last setting, a limited form of shutter-priority automation, lets you set such ultra-fast speeds as 1/500,

Continued

The $39 Duplex SpeakerPhone



Here's the latest in full featured duplex speakerphones. And, wait till you hear the sound.

You're free. You can walk around the room. You can use both hands. You can talk on the phone totally hands free.

Now you can answer your phone by simply pushing a button. And, the sound you'll hear will be crystal clear.

Plus, don't worry about the person you're talking to. You'll speak to them through a high quality condenser microphone that will make you sound like you're sitting right next to them.

TOTAL FREEDOM

Just think about the freedom. You can read your mail, work with your hands or move over to your easy chair while you talk. Plus, you can have a conference call at work or let the whole family talk and listen at one time to someone far away.

TRUE DUPLEX

Most speakerphones are simplex which simply means that when you are talking, you can't hear the other person. So, you're likely to cut each other off.

This all new speakerphone from Callmate is true duplex. With duplex, you and the person you're talking to can interact and talk without pausing.

So, for your office, workshop, study, bedroom or kitchen, it's the ideal phone. It simply plugs into any standard modular phone jack and AC outlet.

It uses universal pulse dialing that works anywhere. Plus, it has last number redial, mute, a ringer off switch and a full range volume control. There's even a jack on the back so that you can plug your own phone into the speakerphone.

It also has a high quality LED digital clock complete with 24 hour alarm and high/low dimming. It's sharp looking, great sounding and backed by Callmate's standard limited warranty.

SET YOUR HANDS FREE RISK FREE

You've got to hear the sound. You've got to experience the convenience of this phone. If you aren't 100% satisfied, simply return it in its original box within 30 days for a courteous refund.

To order your Callmate Hands Free Duplex SpeakerPhone and Clock risk free with your credit card, call toll free, or send your check for DAK's breakthrough price of just **$39** ($4 P&H) Or. No. 9786.

Audio Telescope

Pick a voice out of a crowd or a sparrow's song out of a tree with this super-directional shotgun microphone.



It's tough. If you've ever tried to record a singer while you're sitting in the audience, or a conversation from across the yard, you know that your microphone seems to pick up everything but what you want to record.

Now you can record a lecture from the back of the room or a bird's chirp from across a field.

The sound will be crystal clear with a full 30 to 15,000hz frequency response from this super-directional electret condenser microphone.

Electret condenser microphones capture sounds never before possible outside the recording studio. By using battery driven circuits, these microphones can use a more sensitive sensing membrane to capture sound vibrations.

Very little mass must be moved, so these new mikes are incredibly sensitive. The Audio Telescope is powered by one AA battery (not included).

It comes with both a conventional mike stand mount and a stand. And, you can mount it on most video cameras.

The microphone itself is totally isolated from the stand by polymer O-rings. So, it actually floats. It will not pick up motor noises or vibrations.

It is 17" long and comes with a full length foam wind screen. There is a mini phone plug for video camera use, plus a 20 foot mike cable with both mini and 1/4" plugs for conventional professional recording. It's backed by a manufacturer's standard limited warranty.

TRY THE AUDIO TELESCOPE RISK FREE

Record lectures, concerts or nature, risk free. If you don't feel you've made totally professional recordings, simply return the Audio Telescope in its original box within 30 days for a refund.

To order your Audio Telescope risk free with your credit card, call toll free or send your check for only **$67** plus **$3.50** for postage and handling. Order No. 9736.

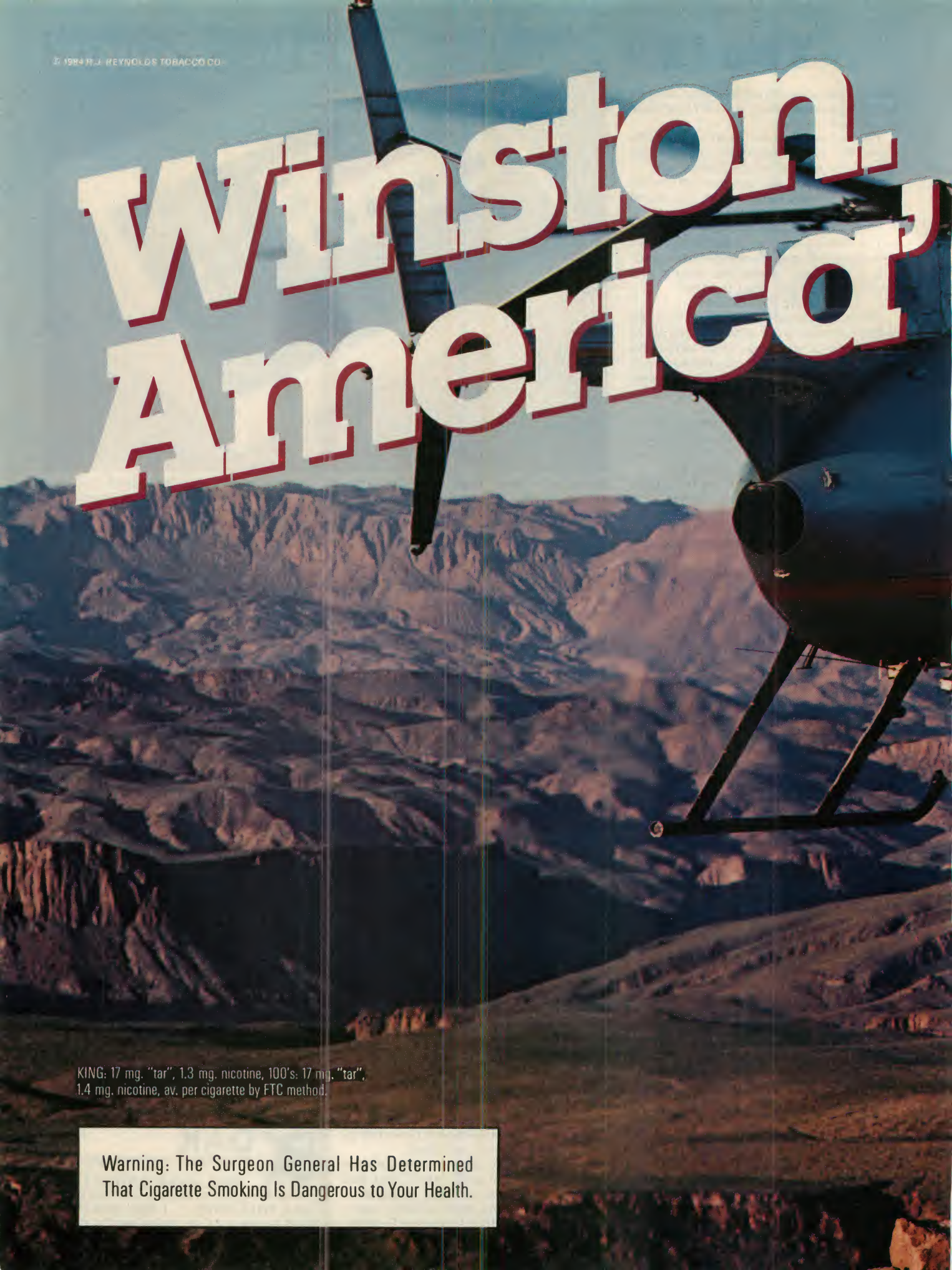
You'll be able to make superb recordings that were never before possible.

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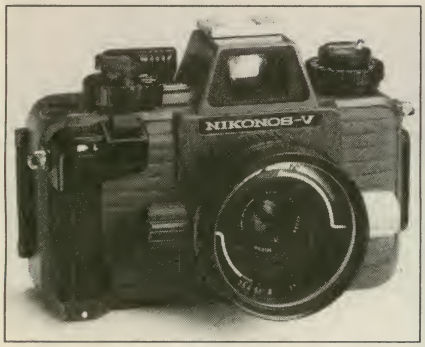
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Warning: The Surgeon General Has Determined That Cigarette Smoking Is Dangerous to Your Health.


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FILTERS
FULL RICH
TOBACCO TASTE
100's

Through the Viewfinder







1/1000, and 1/2000 second and have the camera figure out the lens aperture.

Still another unique feature is the XR-P's multi-function self-timer. Set it to zero, and it's a left-hand shutter release—handy both for southpaws and for those who like to use their flash off-camera, manipulating the flash with the right hand and the camera with the left. Turn the self-timer counterclockwise, and it becomes an intervalometer, providing precise shooting rates of two, 15, or 60 seconds for sequence photographs.

List price of the Ricoh XR-P with f/1.7 lens is $500.

Dry-land and wet Nikons

The brainiest Nikon around may well be the FA, with an ultra-sophisticated computerized program that modifies exposure in unusual lighting situations ["Viewfinder," PS, Dec. '83]. Now there's the Nikon FG-20 (photo, left), specifically designed for beginners. It comes with both manual and aperture-preferred automatic exposure. In the latter mode, a beeper sounds to warn of over- or under-exposure. With f/1.8 lens, the FG-20 lists for $275.

Take a camera into the sea, and you find that the colors, filtered out by the water, slowly fade as you go deeper and deeper. Red goes first, then green. Finally all that's left is blue. That's why you need a flash for pictures, and that's why the new Nikonos-V, with automatic through-the-lens flash exposure (when used with the new Nikonos SB-102 Speedlight), is so significant. The TTL system provides full control in both normal and close-up photography at any lens opening.

The Nikonos-V can be used in both automatic- and manual-exposure modes. Five speeds, from 1/30 to 1/1000 second, are available in the latter mode. It accepts 15-mm f/2.8 and 28-mm f/3.5 UW lenses for underwater use only, 35-mm f/2.5 and 80-mm f/4 Nikkors for amphibious use, and a 28-mm f/2.8 LW lens for above-water use only. Most older Nikonos lenses can be used with the new model.

The Nikonos-V lists for $462 without lens. The SB-102 flash is $845.

Pentax Program Plus

Why the "plus" in the name of the new Pentax Program Plus SLR? It means that the camera offers programmed automatic exposure plus aperture-priority automation, manual exposure, and programmed automatic flash exposure. The viewfinder displays both aperture and shutter speed in the programmed mode—a nice feature (if you care about such things). In manual mode the viewfinder displays the shutter speed in one panel plus a number to show, in f/stops, whether your exposure is off and by how much. With





50-mm f/1.7 lens, the Program Plus lists for $406.

Canon's fastest gun

Any time you've got $8,000, or a good part of it, to spend and need a camera that will shoot 14 frames a second, look into Canon's new F-1 High-Speed Motor-Drive camera. It's the world's fastest off-the-shelf 35-mm SLR. The key to its speed is a stationary pellicle mirror. The mirror both transmits light—enough to expose the film—and reflects light to the viewfinder for framing and focusing. Because the mirror doesn't move—is not locked up out of the way as with other ultra-high-speed film drives—there's no viewfinder blackout, and the photographer can follow the action continuously.

Metering is manual; the camera works too fast for automatic diaphragm operation and full-aperture metering. There are three shutter speeds: five, 10, and 14 frames per second.

Who has the fastest film?

- Fuji. The Japanese film maker, smarting since Kodak beat it to the 1000 ASA mark in 1982, has introduced Fujicolor HR1600, the "world's fastest 35-mm color-print film." And to keep its competitors off balance in the press-agentry department, Fuji has *announced* the "world's fastest color-reversal film, Fujichrome 1600 Professional D."
- Kodak. The U.S. contender is introducing Ektachrome P800/1600 Professional. You can shoot it at speeds of 800, 1600, or 3200, with successive increases in push-processing times. PS



Answering Bombshell

The telephone answering unit just took a quantum leap. Introducing our choice for the finest system.

At first we yawned. We've seen just about every telephone answering unit made. But, what we quickly discovered about the Anova phone answerer made us realize that this exciting new product will change an industry. Here's why.

The Anova combines every desired electronic telephone feature with every desired answering feature and puts them together with beauty and class. True it's not cheap. But compare the total number of features and only then will you realize its great value.

Let's start with the built-in telephone. It has a sixteen-number dialer capable of both pulse and tone dialing. It features one of the best built-in hands-free speakerphones with excellent voice quality that reduces the echo effect common to other units. And its display shows you the number you dialed and the length of your call in minutes and seconds. There is also a hold button that blocks your voice, but lets you hear the other party.

We particularly liked the hands-free speakerphone. It is one of the few full duplex systems which means that both parties can talk at the same time without the annoying voice clipping found in other units. And then there's the shape and feel of the phone—a sculptured piece of art that sounds as good as it looks and feels. If we're a little too enthusiastic, we plead guilty. The Anova is an incredible telephone—but wait.

The Anova is also a telephone answering unit that will not only work at home but in your office. The mini cassette system holds up to seven different outgoing messages. At the office you can record a message for use during lunch, while in a meeting or away on a trip. At home, you can record one message for when you're walking the dog and one for when you're out for the evening. One message can announce that your tape is full.

The unit uses controlled VOX which means that a caller can leave a message from 30 seconds to a controlled limit of 3 minutes or as long as you want. And the heavy-duty tape transport system is so well designed that its recordings sound great, and the system will accept up to 30 minutes of messages per side without having to change your tape.

You can retrieve your calls with a remote pager from any telephone in the world. That's no big deal. But with the Anova, if there are no messages waiting for you, your unit will alert you to hang up and thus save you the cost of a call and possibly long distance charges. And if your unit answers, it will remotely playback all of your messages, skip, repeat or even erase them—all using the remote pager.

At home the time and date of each call received by your answerer is recorded and displayed on the screen as you replay your messages. This saves time because you never have to ask the caller to leave the time or date. You won't realize how nice this feature is until you use it. You can also record conversations, and your unit can automatically redial busy numbers at intervals until you reach your party.

We enthusiastically feel that this telephone and answering system is the most advanced and yet the greatest value of any unit we've examined. But there's even more. The Anova can be attached to a security system console that can turn lights on and off and sense intrusion or fire—and then dial out for emergencies. We'll send you more details of this expansion capability—but the point is simply this. The Anova phone answerer is only one building block of an exciting phone communications and security system that is years ahead of anything we've ever seen.

With its incredible array of features, the Anova also makes sense for your office as well as your home. A phone answerer on your desk lets you retrieve messages without disturbing anybody and the unit will work on all Centrex or Horizon lines and most office communication systems.

And Anova's beauty with its sculptured design will look good on your desk. Anova is a subsidiary of a top 500 US public corporation and this system is an important new product for them.

Add up the many phone and telephone answering features, price them all and you'll see that they total well over $600. You get value, style and an awful good piece of equipment—all for a very reasonable price. But you'll never appreciate our enthusiasm until you personally use it in your home or office and we'll give you that opportunity to find out.

Order one from JS&A. When you receive it, see how convenient it is to have all the telephone features you'll ever need in a single instrument. Use the telephone answering unit and see how you can easily retrieve messages with the thin pocket pager. See how the visual display prompts you through the auto dialer's programming steps; how convenient it is to have the time and date of each message on your answering unit when you arrive home; how the hands-free duplex speakerphone lets you converse hands-free in a normal voice without the on/off switching so common to other speakerphones.

Then decide. If it's not more than we've described, return it and we'll refund your full purchase price including our postage. But if you react like we did, you'll really be enthusiastic about the system. Then, later examine the information on the security module that plugs in together to form a complete communications system. We'll have complete information for you when you receive your unit.

Turn your telephone into a phone answering command station with the Anova—a product that is truly an answering bombshell. Order one at no obligation, today.

To order, credit card holders call toll free and ask for product by number shown below or send a check plus $5 for delivery.

Anova (1160P) **$399**

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POPULAR SCIENCE CAR TEST #183
Total cars tested to date: 668

Detroit vs. Europe:

luxury sports coupes

In the U.S. the status-sedan concept is changing. Today big-ticket buyers are demanding sparkling engine performance, taut handling, and acceptable fuel economy. Europe's luxury coupes have had these qualities for years. POPULAR SCIENCE pitted two U.S. challengers—the new Lincoln Mark VII and Cadillac Eldorado Touring Coupe—against one of Europe's finest automobiles, the BMW 633CSi.

By JIM DUNNE
and JACK KEEBLER
Photos by Greg Sharko

The United States continues to imitate Europe in new-car designs, and nowhere is this trend more apparent than in the luxury-sports-coupe class. Lincoln, with its startlingly different 1984 Mark VII, and Cadillac, to a lesser degree with its Eldorado Touring Coupe, are acquiring a European flavor with design changes that were unthinkable only a few years ago.

How close are these U.S. luxury coupes to meeting the best of the European types? We took the Mark VII and Eldorado to our Bridgehampton, N.Y., test site to match them against the BMW 633CSi, a comparable-size sports coupe that is considered one of the best in the world in its class.

What we found was surprising. The Mark VII, with its revolutionary air

Continued

Luxury sportsters (clockwise from bottom): BMW 633CSi, Lincoln Mark VII, and Cadillac Eldorado Touring Coupe.



Magic Baloney

It had no digital readout, an ugly case and a stupid name. It almost made us sick.



The standard, yucky Magic Stat.



The new deluxe Super Magic Stat.

You're probably expecting our typical sales pitch, but get ready for a shock. For instead of trying to tell you what a great product the Magic Stat thermostat is, we're going to tear it apart. Unmercifully.

When we first saw the Magic Stat, we took one look at the name and went "Yuck." We took one look at the plastic case and said "How cheap looking." And when we looked for the digital readout, it had none. So before the salesman even showed us how it worked, we were totally turned off.

REAL LOSER

So there it was—at first blush a real loser. But wait. We did find one good feature—a feature that led us to a discovery. The Magic Stat installs in a few minutes and no serviceman is required. Thermostat wires in your wall follow standard color codes. So when you install Magic Stat, you attach the red wire to the red location and the white to the white. That's playschool stuff. And it's safe. Conventional thermostats installed over the past 20 years are generally only 24 volts, so you can either turn off the power or work with the "live" wires without fear.

OK, LET'S TEST IT

The Magic Stat installation was so easy that the least we could do was test it. And that's when we made an incredible discovery. We discovered that the Magic Stat was probably the most consumer-oriented, technologically-advanced and most sophisticated thermostat ever developed on the face of this earth and in our galaxy for all times ever. What made us switch from hating the thing to loving it? Read the following.

The Magic Stat has six setback settings per day and a seven day program. This means that in winter you could set it for 70º when you get up in the morning, drop the temperature to 54º when you go to work, raise it to 68º when you return for dinner, raise it up to 72º after dinner as you watch TV and then drop it down to 62º when you go to sleep. Count them—five settings with one to spare.

In one day the Magic Stat is programmed for the whole week and for weeks to come. If you want a different schedule for weekends, you can individually program the thermostat for those days, too. "Big deal," you might think. "What's so great about that?" Read on.

You set most electronic setback thermostats to the time you want the furnace to go on in the morning, so when you wake up, your room is once again warm. But what if one morning it's bitter cold outside and the next morning it's much warmer? This means that setting your furnace to go on at the same time may, on one morning, leave you cold and on the next morning cause you to waste energy by warming up your house too soon.

By golly, the Magic Stat has everybody beat on this one too. Throughout the night it senses and computes the drop in temperature and the time it will take to get your room to your exact wake- up temperature. So if you want to wake up at 7 AM to 70 degrees—that's the temperature you'll wake up to every time. Because it's a patented concept, no other thermostat has this feature. But wait. There is also a patent on the setting feature.

SIMPLE TO SET

To set the thermostat, you press just one button. A small LED light scans the temperature scale until you reach your desired temperature and then you release the button. You change the temperature naturally, throughout the day, up to six times. The unit responds and remembers that exact living pattern. The present temperature is displayed by a glowing red LED on the scale.

The system also computes the ideal length the furnace should stay on to keep the temperature within a range of plus or minus one and one-half degrees. A battery backup lets you keep your stored program in its memory so power outages as long as eight hours won't let your unit forget. And if something happens and your power is out for a few days, the unit will automatically maintain 68 degrees when the power is restored.

Energy savings are also possible in summer when the Magic Stat controls your air conditioning system.

Quite frankly, we were so impressed with the unit, its ease of installation and setting plus its many energy-saving features, we seriously considered advertising it until we realized that our customers would probably not want to trust their future comfort to a product called Magic Stat. What if something went wrong with the unit? How substantial was this Magic Stat outfit? Remember, a thermostat is something you live with as long as you live in your home, and they're supposed to last ages. After all, your comfort depends on it.

Well, we did our homework, We found the company to be a sound, well-financed organization. They have been in business for several years, and they back their products with a three-year limited warranty. In addition, the company has a policy of buying back your unit in one year if you haven't saved its full cost in energy savings. We were satisfied with the company, the people, the product, its incredible features, the company's commitment to the product and above all, the energy savings.

We are so impressed now with the Magic Stat that we're going to make buying one irresistible. Buy one from us for only $69. Install it yourself in a few minutes or hire a handyman to install it.

Or order the new Super All-Season Magic Stat that switches between your furnace and your air conditioning system automatically. You set it once for the whole year and forget about it.

Then enjoy the savings all year long, Not only will you save up to 30% on your utility bills, but you're eligible for the 15% energy tax credit. Then if you're not absolutely in love with this product one year later, return it to JS&A. You'll get all your money back and you can reinstall your old thermostat.

REALIZE SAVINGS

But we're counting on a few things. First, you will realize an energy savings and a comfort that will far surpass what you are currently experiencing. Secondly, you probably will sleep better breathing cooler air yet wake up to just the right temperature.

Beauty is only skin deep and a name doesn't really mean that much. But we sure wish those guys at Magic Stat would have named their unit something more impressive. Maybe something like Twinkle Temp.

To order, credit card holders call toll free and ask for product by number shown below or send a check plus $4.00 for delivery.

Magic Stat (0040P3) **$69**
Super All-Season Magic Stat (0042P3) . . . **99**

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A LASTING



It's a fact: Of the nearly 37 million trucks on America's roads, over 12 million are Fords.*

Why are there so many Ford trucks around? Two reasons: First, they're tough. And second, because they're tough, they're very popular.

Over the last fifteen years, in fact, Ford is first in total truck line sales.* We make the best-selling line of pickups, the best-selling vans, and the best-selling full-sized 4 x 4's in America.**

And, we make them all extremely well.

You're going

*Based on R.L. Polk & Co. cumulative truck registrations.
**Based on manufacturers' reported retail deliveries for CY 1983.
†Based on a survey of owner-reported problems during the first three months of ownership of 1983 vehicles.

QUALITY.

One out of every three trucks on the road is a Ford.



You see, our commitment to quality is more than just a slogan. It's a program that includes everyone and everything in our company. And it has achieved real results.

An annual survey has shown that Ford is making the highest quality cars and trucks of any major U.S. manufacturer.†

So visit your Ford dealer soon. We think you'll find the quality you're looking for.

The kind that lasts.

to love the quality. Ford **Quality is Job 1.**

FORD • LINCOLN • MERCURY •
FORD TRUCKS • FORD TRACTORS

PS ratings—test report in a nutshell

The ratings are based on test results and measurements. Results should be read with the understanding that they reflect tests only on our sample cars. An excellent rating is 5 points; very good, 4; good, 3; fair, 2; poor, 1; very poor, 0.

	BMW 633CSi	Cadillac Eldorado Touring Coupe	Lincoln Mark VII
Acceleration	5	4	5
Braking	2	3	3
Handling	4	2	5
Maneuverability	5	5	5
Quietness	3	4	5
Roominess	3	4	4
Vision	5	2	3
Entry/exit ease	3	4	2
EPA economy	3	3	3
Ride comfort*	5	4	5

*Authors' opinion

springs, gave the 633 a good race in every important category save one. But the "sports" Eldorado seemed cushy to a fault, despite its stiffened suspension. As you might expect, both American coupes bettered the European in comfort and convenience features. These include such things as interior quietness, electric-seat adjustments, adjustable steering columns, automatic suspension leveling, and automatic light systems.

Although fuel economy isn't usually a major concern for buyers of big-ticket coupes, all of the engines in this group are smallish by standards of a decade ago, and as a result fuel economy is better. Fuel-mileage readings from our 55-mph steady-speed tests were close to the EPA city-mpg number—in the 18-to-19-mpg range. However, our steady-speed results at 35 mph, a test that should show the best economy these cars can produce, were in the 22-mpg range. That's far below the official EPA ratings of 27 to 29 mpg for highway driving.

A strong difference between these models showed up during our fifth-wheel-monitored zero-to-60-mph runs. In acceleration, BMW is the clear winner. A refined 196-cu.-in. single-overhead-cam engine helped it score an impressive 9.2-second zero-to-60 time.

Mark VII packed the biggest power plant, a well-proven 302-cu.-in. V8. Though not in the BMW class, the Mark VII zipped to 60 mph in 11.7 seconds. That makes the new Mark one of the fastest of its kind ever. It also demonstrates the big advantage gained by peeling 350 pounds off Lincoln's 1983 model.

Cadillac's overextended 249-cu.-in. aluminum V8 is disappointing in the Eldorado Touring Coupe. Its zero-to-60 time is an almost-embarrassing 15.9 seconds.

(Note: PS acceleration-test results are usually conservative in comparison with those of other published car tests. The reason: Our posted time is the average of two runs, north to south. PS also tests with two passengers and a fuel tank that usually is nearly full. Most publications print only their hottest run in a single, possibly wind-aided direction with only the driver aboard.)

Here's how each of the cars feels and looks up close:



BMW luxury coupe smoked straight and true into the brake lane as if it were on rails. Unfortunately the rails seemed slick, with its 170-ft. hot stop.



Mark VII scored excellent grades for both its cold- and hot-stopping distances: The car stopped in a remarkably short 153 ft. and 152 ft., respectively.

BMW 633CSi

BMW's flagship coupe is typical of the German maker's line. The ride is firm, power delivery is smooth, and the five-speed manual is as slick-shifting as you can find.

Yes, it is disconcerting to drive a $40,000 car with a stick shift, but it's all part of BMW's European luxury-sports image. Seat positioning is also manual. (We tested a late-production 1983 model. BMW tells us that '84 models will have power seats.) But don't be misled. This car has some of the most modern and advanced electrical-electronic systems anywhere. These include automatic temperature control, on-board trip computer, coded ignition lock, power-operated mirrors, and cruise control—all at no extra cost. For forgetful owners, a row of green and red lights on the panel signals you when oil changes or chassis inspections are due.

Driver comfort is important to affluent Europeans, too. But they have a different idea of comfort than U.S. drivers do. The passengers sit in firmly padded leather seats that are

Continued

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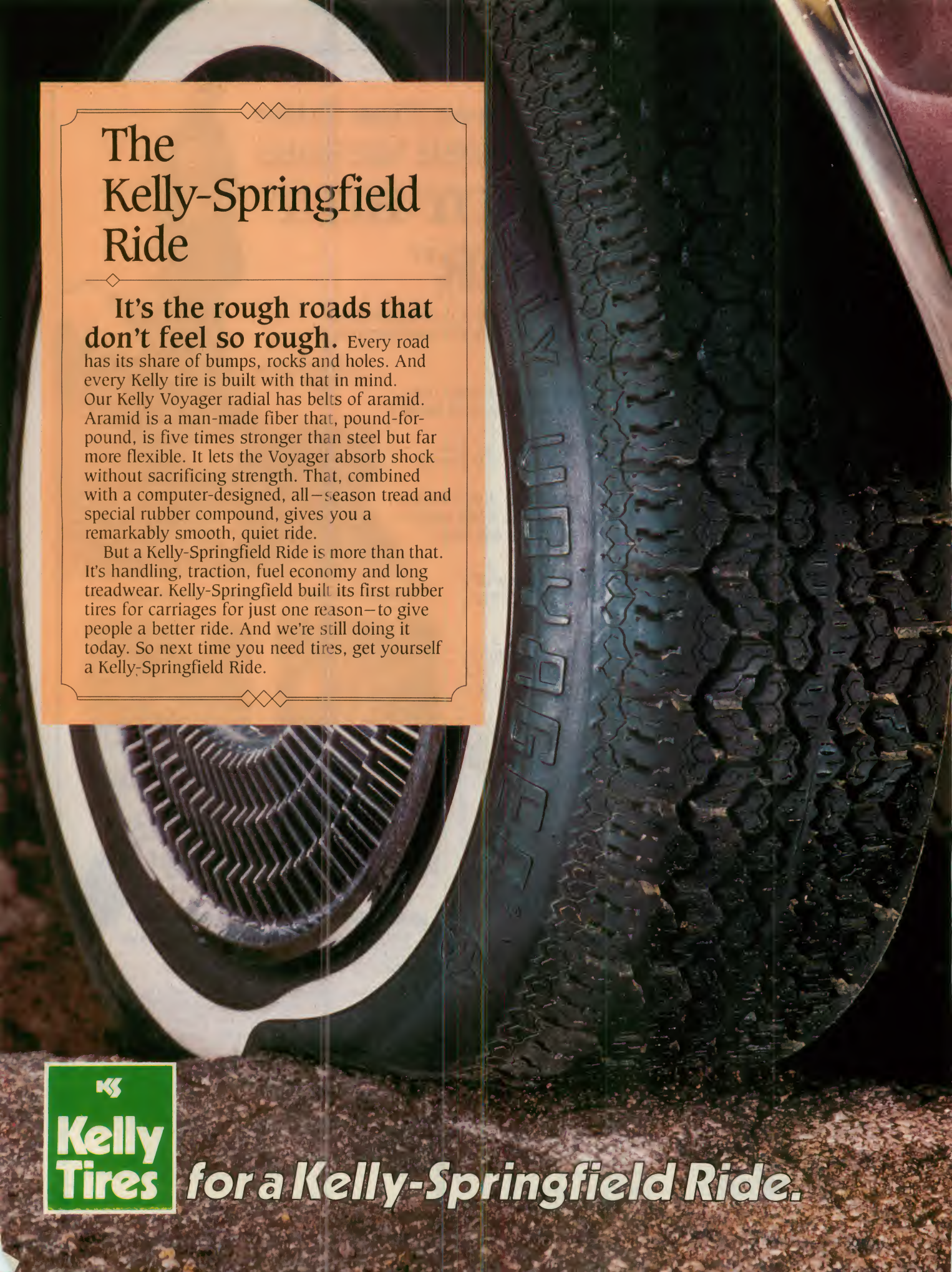
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carefully formed to hold the body in place without feeling confining. Controls and seat adjustments have a feel of sureness and solidity that says "quality" more loudly than any advertising slogan.

We did find one design error. The upper part of the instrument panel was blocked from view by the top of the steering wheel, an uncharacteristic foible for BMW.

Eldorado Touring Coupe

The Eldorado's interior trim and instrument panel seem like a throwback to the old days of the opulent American big cars: There are lots of shiny silver surfaces. This is most evident in the doors, where handles, lock and window switches, mirror controls, and seat controls are finished with chrome brightwork.

Eldorado's instrument panel is another contrast. It's flat, with no contoured section to present the controls more directly to the driver. Light and wiper switches are all a lean-forward distance from the driver, too. Finally, that old favorite of American luxury cars, wood-grain veneer, covers much of the instrument-panel face and parts of the door trim, presenting an interior appearance very different from that of the other cars.

Eldorado's conservative appearance is reflected in its feeble track performance. Its touring suspension is slightly firmer than that of the standard Eldorado coupe, but it was difficult for us to detect any real handling advantage. The car bounces softly when traveling over uneven surfaces and has a slightly awkward steering reaction to power-on, power-off conditions during a turn. Although it's fine for boulevard use, the car is not really in the same road class as the BMW and Lincoln coupes.

Eldorado's power train is slow to respond to the driver's needs. The engine over-revs during downshift situations in which more power is needed. And then there's a shudder as the engine grabs the next gear under full throttle.

Like the Mark VII, the Eldorado has oversize, soft seats. The room inside is excellent, thanks in good measure to the front-drive layout that leaves the floor relatively flat for front and rear passengers. Rear head room and leg room are generous.

Lincoln Mark VII

The Mark VII is a completely new car for 1984 and is a radical departure from Lincoln's luxury barges of the 1960s and '70s.

First, the 302-cu.-in. V8 and four-speed automatic are one of the smoothest drive-line combinations on the domestic scene. The reduced weight of the unit body allows the 302 to develop enough power to give the driver a "light-on-its-feet" impression of the new Lincoln. And handling, ride, and the aerodynamic appearance are just as different from the earlier models.

Let's look at the basics. Mark VII has unit-body construction, air springs, smaller size, lighter weight, smaller interior (seating for four), and the look and feel of a personal car. But luxury is not absent. The interior is one of the most quiet we've ever tested. Score a victory for attention to aerodynamics and air springs.

If you think of air springs as soft, balloon-like bags, you'll be surprised by the Mark's ride and handling. Firmer than any former Lincoln's, the ride is taut without being harsh.

The seating is arranged for roomy four-passenger comfort. This is a switch from the compromised six-passenger coupes that carried the Mark brand in the past.

Along with its radically different aerodynamic appearance, the Mark is the first of a new generation of cars that will sport flush headlight lenses. We didn't notice any appreciable difference in their performance, but they certainly reinforce the car's streamlined aspect.

Two improvements we think would bring the car more in line with its European goal: Reposition the radio and heater controls so they're easier to reach from the driver's seat, and add some additional gauges to complement the on-board computer.

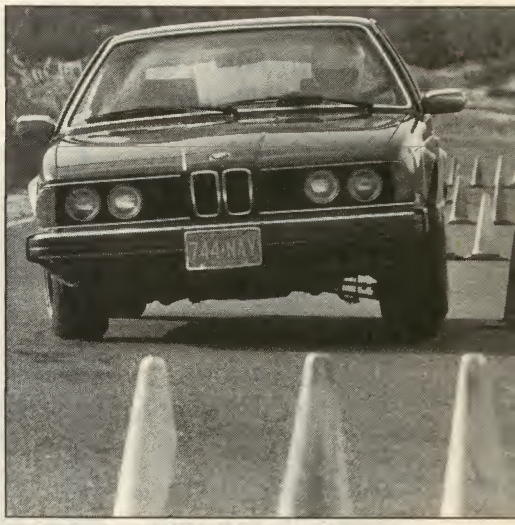
Our picks

Give me those air springs and the proven V8 of the Lincoln Mark VII. It handles well, entry and exit are

Continued



Eldorado's front-wheel drive seemed to provide a maneuverability advantage when it ran the low-speed gauntlet.



BMW's abundant power tempted testers to throttle-steer the vehicle through the tight maneuverability course.



Easily top dog in the high-speed test, the Mark VII was edged out by both competitors in the low-speed run.

Performance comparison with selected 1981 and 1979 models

	Mpg (city driving)	Acceleration 0–60 mph (sec.)	Brakes 60–0 mph (hot) (ft.)	Handling (mph)	Maneuverability (mph)	Noise @ 60 mph (dBA)
1981 Cadillac Eldorado V8	17	16.5	223	62.3	27.6	68
1981 Lincoln Mark VI V8	16	16.0	205	59.0	27.0	72
1981 Chrysler Imperial V8	16	15.8	233	60.0	27.4	69
1979 BMW 633CSi in-line 6	13	10.3	140	60.0	29.1	68
1979 Mercedes 450 SEL V8	12	12.9	163	60.0	27.6	69

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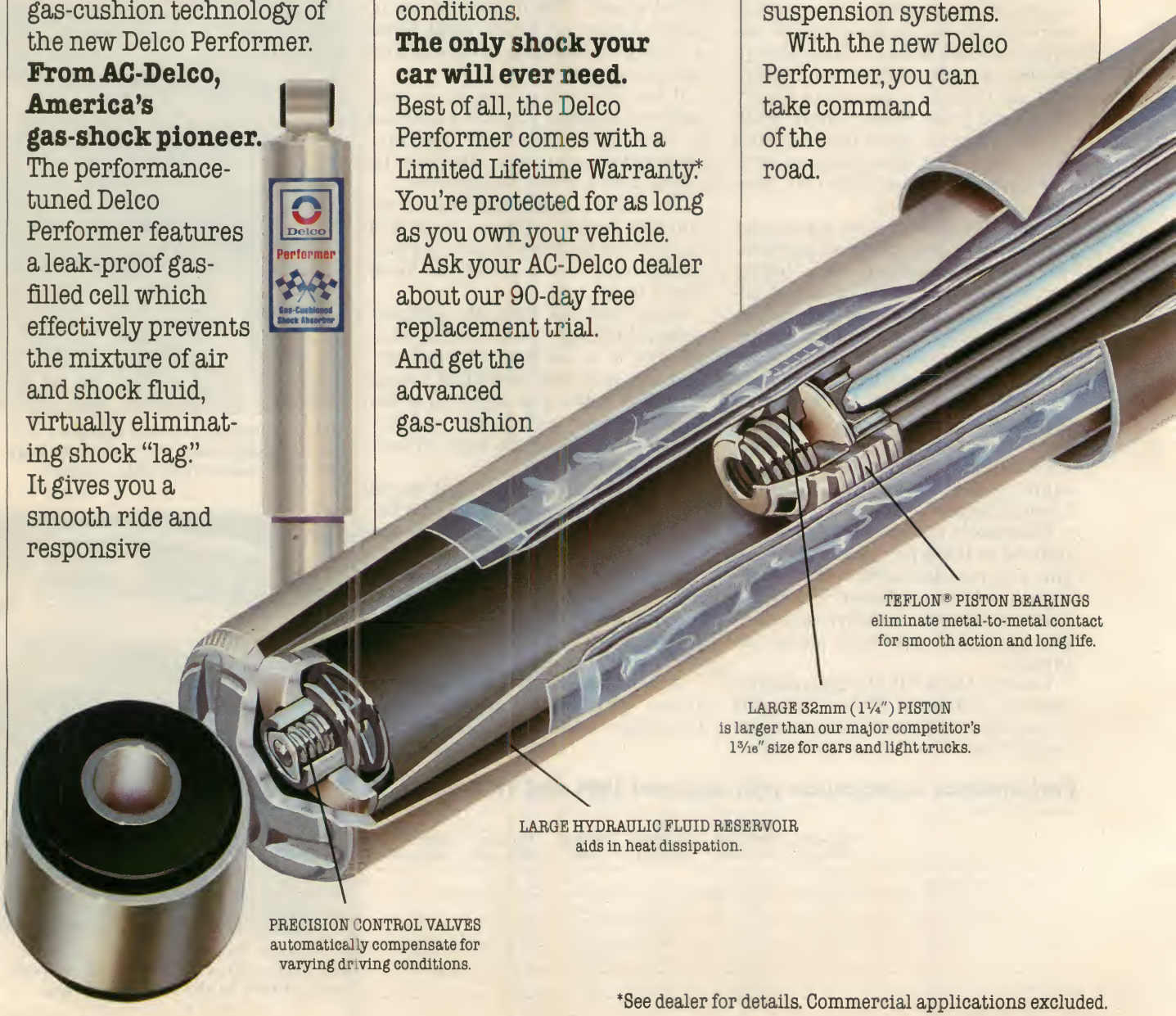
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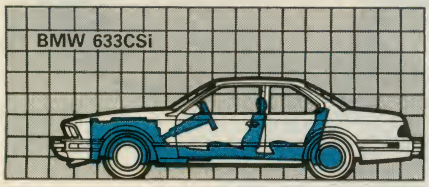
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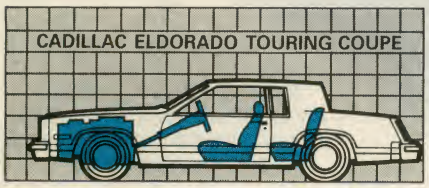
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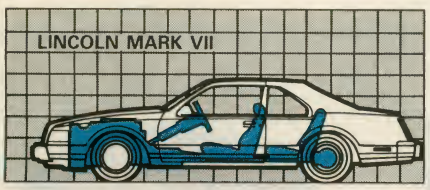
Chuck Yeager, Brig. Gen. USAF (Ret.).
One of America's greatest test pilots, active consultant to the Air Force, NASA and major aircraft manufacturers.

easy, and acceleration is good.—J. D.

It's Mark for the money. But as a former BMW mechanic, I fell in love all over again with the powerful, smooth-running six and classic styling of the 633. Too bad the price is so outrageous.—J. K. PS







ILLUSTRATIONS BY RUSSELL VON SAUERS

PS serviceability ratings

How easy is it to service these cars? To give you an approximation of how difficult it is for a typical person to perform various service operations, we examine each test vehicle. The numbers mean: 1, very difficult; 2, difficult; 3, average degree of difficulty; 4, easy; 5, very easy.

	BMW 633CSi	Cadillac Eldorado Touring Coupe	Lincoln Mark VII
Checking fluid levels			
Battery	5	5	5
Master cylinder	5	5	3
Windshield washer	5	5	5
Engine oil	5	3	5
Coolant	5	5	5
Checking the engine			
Spark plugs	2	2	4
Distributor	5	3	5
Oil filter	2	2	3
Oil fill	5	2	5
Replacing hoses			
Upper radiator hose	5	3	5
Lower radiator hose	3	3	4
Heater hoses	3	3	4
Changing bulbs			
Headlights	3	3	5
Taillights	4	3	5
Front running lights	3	3	5
Front parking lights	3	3	5
Front directionals	3	3	5
Rear directionals	4	3	5
Rear running lights	4	3	5
Checking fuses	5	2	4
Spare-tire accessibility	5	3	4
Changing belts	2	3	4

Test results, dimensions, and specs

	BMW 633CSi	Cadillac Eldorado Touring Coupe	Lincoln Mark VII
TEST RESULTS			
Acceleration (sec.)			
0–60 mph	9.2	15.9	11.7
Brake test (cool) 60–0 mph			
Stopping distance (ft.)	182	187	153
Pedal pressure (lbs.)	120	120	100
Brake test (hot) 60–0 mph			
Stopping distance (ft.)	170	160	152
Pedal pressure (lbs.)	110	120	80
Interior noise @ 60 mph (dBA)	68.0	65.5	65.0
Handling test (mph)	63.6	57.6	70.0
Maneuverability test (mph)	29.0	29.6	28.3
EPA FUEL MILEAGE (mpg)			
Highway	29	28	27
City	19	18	17
Calif. city	19	17	17
PS FUEL-MILEAGE TESTS (steady-state mpg)			
35 mph	22.3	21.8	—
55 mph	18.5	19.0	—

NOTE: POPULAR SCIENCE fuel-economy results are derived by driving the test vehicle over a flat, measured mile at sea level. Fuel consumption is measured using Pierburg PLU-116 liquid flowmeters with an accuracy of plus or minus 1.0 percent of actual flow rate. To eliminate the effects of wind, we average consumption after two north and two south runs.

TEST CONDITIONS Ambient temperature, 45° F; relative humidity, 67 percent; barometric pressure, 29.2 inches Hg

DIMENSIONS (inches)			
Wheelbase	103.4	114.0	108.6
Overall length	192.7	204.5	202.8
Overall height	53.7	54.3	54.0
Overall width	67.9	70.6	70.2
Track, F/R	56.0/58.5	59.3/60.6	58.4/59.0
Ground clearance	8.5	6.4	7.3
Front head room	34.0	37.9	37.8
Front hip room	46.0	51.8	52.4
Front leg room	43.0	42.8	42.0
Rear head room	34.0	37.9	37.1
Rear hip room	52.0	48.9	55.2
Rear leg room (min.)	33.0	39.1	36.9
Rear knee room (min.)	−1.5	3.2	3.2
Couple distance	26.0	34.5	34.2
SPECIFICATIONS			
Engine type	In-line SOHC 6	V8	V8
Displacement (cu. in./L)	196/3.2	249/4.1	302/5.0
Compression ratio	8.8:1	8.5:1	8.4:1
Carburetion	F.I.	F.I.	F.I.
Net hp @ rpm	181 @ 6,000	135 @ 4,400	140 @ 3,200
Net torque (ft.-lbs.) @ rpm	195 @ 4,000	200 @ 2,200	215 @ 1,600
Transmission	5-speed manual	4-speed automatic	4-speed automatic
Axle ratio	3.25:1	3.15:1	3.27:1
Tire make	Dunlop	Goodyear	Goodyear
Tire type	SP Sport Super D6 radial	Custom Polysteel radial	Eagle GT radial
Tire size	205/70R14	225/70R15	215/65R15
Steering	Power, ball and nut	Power, recirculating ball	Power, rack and pinion
Overall steering ratio	15.7:1	14.0:1	16.4:1
Turns, lock to lock	3.20	2.90	3.05
Turn diameter (ft.)	33.1	38.4	40.0
Front suspension	Independent, telescoping staggered legs, coil springs	Independent, torsion bars	Independent, modified MacPherson struts, air springs
Rear suspension	Independent, telescoping legs, coil springs	Independent, trailing arms, coil springs	Rigid axle, air springs
Front stabilizer-bar diameter (in.)	n.a.	1.10	1.12
Rear stabilizer-bar diameter (in.)	n.a.	0.87	0.65
Brakes	Power, disc-disc	Power, disc-disc	Power, disc-disc
Brake swept area (sq. in.)	n.a.	395.8	439.1
Fuel tank (gal.)	16.5	22.8	22.3
Trunk space (cu. ft.)	18.7	15.0	15.0
Liftover height (in.)	30.5	28.9	29.8
Curb weight (lbs.)	3,350	3,734	3,625
F/R weight distribution (%)	56/44	60/40	57/43
Basic price	$40,705	$20,342	$23,900
Price as tested	$40,705	$24,921[1]	$25,950[2]

Major options (over $100): [1]Electric mirrors $101, vanity mirrors $140, tilt wheel $184, cruise control $185, theft deterrent $190, rear defogger and heated mirror $215, six-way power seat $225, digital instrument cluster $238, AM-FM-cassette stereo $229, Touring Coupe package $1,975; [2]CB radio $154, visor vanity mirrors $156, electronic AM-FM cassette $170, compass-thermometer $191, premium sound system $206, six-way power seats with recliners $416

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If you're thinking about 4-wheel drive, consider this. The all-new leaner, meaner size Jeep Cherokee has just been named "4x4 of the Year" by all three leading off-road magazines: 4 Wheel & Off-Road, Four Wheeler, and Off-Road. That's never been done before.

Ride and drive is what it's all about.

The all-new Cherokee was compared to the toughest competitors available, foreign and domestic. They were driven thousands of miles through snow, soft sand, subfreezing temperatures, and high winds—on and off the road.

4 Wheel & Off-Road said: "Cherokee scored well across the board, excelling in our evaluations of mechanical, urban and off-road driving and interior comfort." Four Wheeler called the Cherokee Sportwagon: "the year's most significant advance in 4-wheeling." Off-Road said: "Jeep is a smaller, more maneuverable off-road vehicle that provides plenty of room."

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Compared to Bronco II and S-10 Blazer 4x4, only Cherokee has four doors, room for five, and a choice of two 4-wheel drive systems. And Cherokee has higher ground clearance, higher horsepower per pound, and the highest gas mileage, (24) EPA EST MPG/ 33 EST HWY.*

It's nice to be named No. 1, but not unexpected. After all, Jeep wrote the book on 4-wheel drive. Buy or lease the triple award winning Cherokee, or the luxurious new Wagoneer Sportwagons. Only at your Jeep dealer.

*Use these figures for comparison. Your results may differ due to driving speed, weather conditions and trip length. Actual highway mileage and California figures will probably be less.

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BMW's 3-series grows up

TUCSON, ARIZ. The sun drenched the rugged terrain, and majestic saguaros streaked by the car window in a blur as my driving partner and I began our ascent up Mount Lemmon. The car muscled its way up steep inclines and easily smoothed out S curves and hairpin turns as we attacked them on our way to the 9,000-foot summit.

This was the high point of a 250-mile test drive of the newest BMW to appear in the States, the 325e. And what better place to introduce a sporty car than Tucson, with its city streets, desert highways, and winding mountain roads in such close proximity?

Like the other 3-series automobile known to Americans, the four-cylinder 318i, the new car is a compact sports sedan. But this Bimmer sports a high-torque 2.7-liter (164-cu.-in.) six-cylinder engine, five-speed transmission with "tall" gearing, the brand-new ZF 4 HP 22 four-speed automatic transmission as an option, a nine-function on-board computer, new sports seats, and stiffer independent suspension than the 318.

The big news is the six-cylinder "eta" engine, which first appeared in the BMW 528e. Eta, the Greek letter η, is the engineering symbol for efficiency—hence the "e" in the car's name. The idea behind the engine is to combine high performance with good fuel economy. This is accomplished by making the engine a high-torque engine: It delivers its greatest power at low rpm, and lower engine speed means better fuel efficiency. I felt the effect of this low-end power as I easily sped along the steep mountain roads.

To maintain the reduced engine speeds BMW engineers selected a low (2.79:1) final-drive ratio, or tall gearing, for both the manual and four-speed automatic transmissions. The easy-shifting five-speed was pleasant to use, with plenty of available power in any of the first four gears. I have one complaint, though. The rev limiter, which cuts off engine power without warning, is set at a low 4,700 rpm. I found this to be disconcerting during my test drive, and it could be dangerous—when passing in a low gear, for instance.

The 325e is touted as a *sports* sedan. As such, it should have a tight suspension that responds to your every whim. You won't be disappointed here. The ride was firm yet smooth, and steering response was sensitive without being twitchy. Even on the most circuitous roads the car held without a hint of breakaway, and I felt in complete control at all times.

The overall high quality of the 325e is typical of BMW. Seating is firm and comfortable, and instrumentation layout is impeccable. (Oddly, though, BMW seems to have an aversion to ammeters, temperature gauges, etc.) The nine-function on-board computer, which calculates average speed, average fuel consumption, and range on remaining fuel, among other things, is a nice touch. In fact, we used the stopwatch feature to time zero-to-60-mph acceleration and got a respectable 9.7 seconds. (The official BMW time is 9.4 seconds.)

In all, this is a fine car. But you pay for what you get. The base price is $20,970.—*Timothy O. Bakke*



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"Say, Smokey—"

A clinic on cars by Smokey Yunick, America's most famous mechanic

Cold-blooded

I have a 1979 Pontiac Bonneville and couldn't ask for a better-performing car when it's warm, but when I start it cold it must be warmed up for four to five minutes or it jerks, spits, and stumbles. Two recent trips to the dealer haven't helped. Any suggestions?
Arthur P. Williams Jr., Ithaca, N.Y.

Your problems are leanness and cold. The carburetor air and intake manifold need all the heat they can get on a cold start. Setting the choke is not simple; it must be done by the numbers and checked for sequence. You need to be a little rich on a cold start, so the accelerator pump must work correctly. Late ignition timing also hurts a cold start. Are your hoses correctly routed and in good shape? A vacuum leak can hurt cold starting, and you don't want EGR. The exhaust system controls manifold heat, and the water temperature is in that circuit; there could be an incorrect hookup or a bad temperature sensor. The plugs and ignition also need to be on the money, especially for a cold drive-off.

Lower cap pressure safe?

Is it good or bad if I change the radiator cap on my car to one with a lower pressure setting? A hose broke, and a mechanic said the original cap pressure was too high. But another mechanic changed the cap pressure back to the original setting. Who is right?
Jose O. Benitez, Pineview, Ga.

The manufacturer specifies the proper cap pressure. A cap whose pressure is too low will blow off water too soon, and when you lose water the engine gets hot. Too-high pressure will rupture some parts of the cooling system, such as hoses and the radiator. A couple of pounds one way or another is not a big problem. But if you do a lot of stop-and-go driving in warm weather, it's a good idea to put on a higher-pressure cap. The cap doesn't control temperature; it's just a safety valve.

Boiling over

About a year and a half ago my 1978 Chevrolet Camaro started overheating in excess of 200 degrees F. Several changes of thermostat, flushing the block and radiator several times, changing the entire exhaust system, and installing a new water pump haven't helped. I have to keep the heater on during warm-weather driving to keep the temperature down.
Abed Zantout, Sycamore, Ill.

The only way to check a radiator is to have it rodded out; I've never had luck any other way. I'll bet yours is partially plugged. Here's how to check for a compression leak into the water system: With the engine cold, disconnect the water-pump belt, take out the thermostat, and (with the block full of water)



start and rev the engine. If there's no water movement and no bubbles, it's OK. Other causes of overheating include late ignition timing or a worn-out cam or chain. Also look for fan movement, a bad viscous fan drive, or a missing or incorrectly installed fan shroud.

Tire-pressure quandary

The placard on my 1980 Chevrolet Citation indicates that the tire pressure should be 24 psi. The tire dealer says my new P185/80R13 tires should have 35 psi; the tires are marked for 35-psi maximum pressure. However, my gas-station man claims 26 psi is the limit. The tire dealer insists he is correct and tells me that car makers sometimes advise less pressure for an easier ride.

David C. Carmichael, McLean, Va.

Each car maker specifies a certain tire and tire pressure. When you go to a different brand of tire, you have a conflict. Reduce tire pressure and you can ruin tires; increase pressure and you get a rough ride and altered handling characteristics. The moral of the story is, if you change from O.E.M. specs, be sure you know your apples or you're a one-man research lab.

Puzzling oil ratings

Most 10W-40 motor oils are rated for Service SF, and most 10W-30 and single-grade oils are rated for Service SF-CC. Are SF-CC oils superior? Are oils labeled "Service SF-CD" suitable for use in gasoline-powered cars, or would they result in excessive combustion-chamber and valve deposits? Does SF-CD oil contain more detergent-type additives than the others?

John Bebenek, Buffalo, N.Y.

I do not believe that SF-CC-rated oils are superior to SF-CD oils. For example, Mobil 1 is rated SF-CD, and that's a good oil for a car, assuming you have a clean engine in good condition. For those who wish to fully understand oils and lubricants, you can obtain a copy of the Automotive Products Manual, 30th Edition—the Cadillac of lubrication information—by sending $3.50 to Mobil Oil Corp., 3225 Gallows Rd., Fairfax, Va. 22037. The topic's complex, and you'll see why I caution about second-guessing the owner's manual. When you stray from the manual, you'd better know what you're doing.

Engine dies on the road

My 1981 Chevrolet Suburban with a 454-cu.-in. engine cuts out completely for no apparent reason and can only be revived by backing off the throttle, letting it catch its breath, and babying it back to speed. I've replaced the fuel filter and twice had the dealer check things out. Any suggestions?

Chuck Abraham, Omaha, Neb.

First check for an exhaust restriction at the converter, muffler, or tailpipe. The silencer pipe's screen end may be plugged. The other possibility is inadequate fuel-tank venting. When your engine dies, stop, take off the cap, and see if it's OK. If venting is the problem, you'll have to check out the complex plumbing system connecting the tank, engine, and canister.

Got a car problem? Send it to: "Say, Smokey—," POPULAR SCIENCE, 380 Madison Avenue, New York, N.Y. 10017. All letters are read, and those of widest interest are answered in this column. Due to the large volume of mail, Smokey cannot reply to letters not selected for publication.



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Knockdown turbine for remote sites



With its slim tower and thin, curved airfoils, the windmill looks too slight to withstand gale-force winds. But this vertical turbine bears only surface resemblance to the fragile-looking eggbeater patented in 1925 by French engineer G. Darrieus. The 92-ft.-tall, computer-controlled turbine is said to be sturdy enough to be shipped to remote areas, erected in rugged terrains, and operated in foul weather.

The modified eggbeater, developed by Flowind Corp. (Kent, Wash. 98031), can generate enough energy annually to power 20 homes. That's insignificant compared with a giant horizontal-axis windmill such as the MOD-2 ["Wind Farm's First Sprout," PS, Nov. '81], which can power 1,400 homes annually. But the vertical turbine has advantages over such windmills as MOD-2, particularly in remote towns and work sites that rely on costly diesel-generated electricity.

"Unlike most horizontal-axis turbines, the Darrieus design accepts wind from any direction without having to be reoriented," says Tom Hiester, project manager at Flowind. "But the principal advantage is that the heavy equipment is down on the ground instead of up in a tower."

Flowind engineers began with an eggbeater design developed at Sandia Laboratories [PS, May '75] and refined by the Alcoa Corp. [PS, Sept. '78]. "We were looking at a global market," Hiester says, "so we first modified the design to allow the windmill to be shipped in standard 40-foot shipping containers."

The next problem was how to erect the turbine without using a 100-foot crane. Flowind's solution: Assemble the turbine in a flat position, then raise it with a hydraulic jack.

The project engineers also added cable bracing between the central tubing and blades to bolster the 55-foot-diameter rotor. The windmill now should withstand 200-mph winds.

A computer-controlled motor starts the windmill, eliminating the need for the Savonius buckets that were part of the Sandia design. "The computer checks the system every tenth of a second," Hiester says. "If something is wrong, you have a safe shutdown."

In tests conducted for Puget Sound Power & Light Co., the turbine has produced 120 kilowatts in 36-mph winds. Flowind hopes to raise the windmill's peak output to 170 kilowatts.

According to Hiester, the windmill makes sense where power could be sold at from five to seven cents per kilowatt-hour. "The turbine is even more attractive for remote areas in Alaska, where diesel-generated power costs 40 cents a kilowatt," says Hiester.

—*Cathy Stone*

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World oil supply: from famine to glut

The world oil picture has done a flip-flop since the 1970s—a sharp reduction in oil use, spurred by increasingly efficient consumption patterns, has turned the oil famine of a decade ago into a worldwide glut.

After the 1979 oil-price hike, the cost of oil per dollar of goods and services worldwide fell abruptly, reversing a long-standing trend. "The amount of oil required to produce $1,000 worth of goods and services fell from 2.15 barrels in 1979 to 1.74 in 1983, a decline of some 19 percent," said Lester R. Brown, president of the Washington-based Worldwatch Institute. This decrease in use has contributed to an excess in production capacity, with exporters producing more oil than the world can consume at current prices, Brown added.

According to a recent Worldwatch study, the world used 20.5 billion barrels of oil in 1983, a 14-percent drop from the all-time high of 23.8 billion barrels in 1979. The United States registered a 43-percent drop in residential and commercial heating-oil use from 1973 to 1982, reflecting better insulation techniques and the substitution of such fuels as natural gas and firewood. American utilities reduced their oil use by 61 percent between 1978 and 1982, mostly by burning more coal. Also, U.S. gasoline use fell 15 percent from 1978 to 1983, largely because of more-fuel-efficient cars manufactured in response to rising gasoline prices.

A major reason for the worldwide oil glut is the push for increased use of renewable energy resources. Since 1973 wood has steadily displaced fuel oil as a source of residential heat in heavily forested areas. In fact if recent trends continue, said the study, Vermont will be the first state to use more wood than oil for home heating.

Other renewable energy sources enjoying increased use include wind farms and geothermal wells. By the end of 1983 California had 4,600 commercial-scale wind generators with a total generating capacity of 300 megawatts. The state projects an additional 2,500 MW of wind power by the end of the century. Geothermal wells are gaining favor as a source of residential heat: Japan, with some 1,500 hot-spring resorts, is the leader in this area. In addition, 130 geothermal power plants with a capacity of 3,200 MW were in use worldwide as of mid-1983, according to Brown.

"Gains in energy efficiency are welcome at a time when nuclear power, once touted as the energy source of the future, is in trouble everywhere," Brown said. Japan, France, and the Soviet Union, once viewed as nuclear-power successes, are now having difficulties. In the U.S., no new nuclear plants have been ordered since 1976, and more than 90 plants have been canceled in the last nine years.

However, the current world oil glut could become yet another distant memory if tensions in the Persian Gulf were to close the Strait of Hormuz, a major passageway for oil exports. "It would have an immediate psychological effect, and the spot oil price would climb. Europe and Japan, who get much of their oil from that region, would be greatly affected," Brown concluded.—*Jay Blickstein*



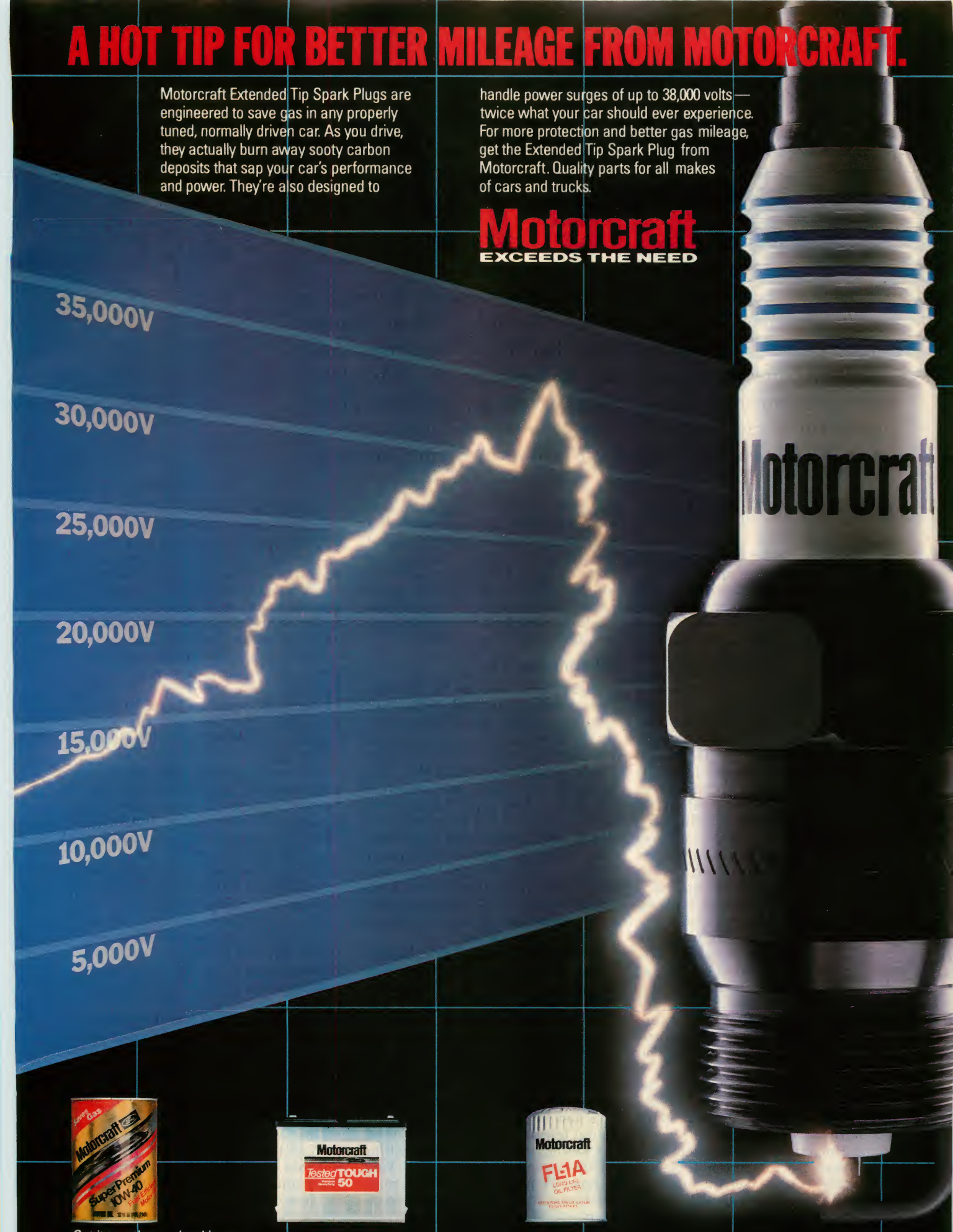
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Get it together — buckle up.

New digital receivers deliver ultimate TV

TV firms are readying receivers with computer chips that replace hundreds of components and process video in digital form. Computerized picture and sound circuits simplify TV alignment, noise and ghost reduction, teletext and videotex reception, and compensation for component aging. They also make possible many totally new features, such as freeze frame, color picture within a picture, zoom, 1,000-line images, automatic VCR programming, and more.

By DAVID LACHENBRUCH

Last fall, at the world's largest consumer electronics show in West Berlin, a Panasonic engineer gave me what looked like an ordinary TV infrared remote control. But when I used it, I learned that the matching 19-inch color receiver that I flicked commands at was far from ordinary.

The set, in a show demonstration room, had all the features of a current high-end model. Glowing in one corner of the main TV picture, though, was a separate five-inch TV image. One of the remote's many functions enabled me to instantly reverse these independent pictures: When I tapped a button, the small picture filled the screen, and the big image collapsed into a corner. But unlike earlier picture-within-a-picture sets I'd seen, with monochrome, coarse, grainy auxiliary images, this prototype model displayed two full-resolution color pictures.

Panasonic's receiver and other TV models at the show were the first glimpse given to the public of the most revolutionary change in television sets at least since the introduction of color —and possibly of all time. These were digital TV sets—in effect, sophisticated computers that act as television receivers.

These digital sets, just entering the market, are based on the same types of super-dense microelectronic chips [PS, April '83] that are fueling a boom in the computer and telecommunications industries. In addition to a long list of new features, such as picture-within-a-picture, digital-TV chips promise cheaper sets with fewer components. Not only can digital sets be adjusted rapidly and automatically at the factory, they can continue adjusting themselves in your home as components age. Even-more-advanced models on the drawing board are expected to merge a variety of electronic products, including the home computer, into a single component.

Siliconizing TVs

At the Berlin show, the Eduard Rhein Prize, presented annually to the year's most outstanding contribution to consumer electronics, went to a jovial, rotund Yugoslavian-born West German engineer named Lubo Micic (pronounced mitch-itch), now known as "the father of digital TV." Micic, managing director of ITT Semiconductors Worldwide, headquartered in Freiburg, West Germany, started development work on digital-TV-signal processing in 1973, when the microprocessor was just two years old. It was part of what he describes as a 14-year program to "siliconize" the TV set.

In 1981 ITT startled the electronics world with the announcement that it had developed a set of five very-large-scale-integrated-circuit (VLSI) chips and two peripheral chips for a television set in which all video- and audio-signal-processing functions were digital. What was so surprising was that ITT's development was virtually completed almost before its competitors had begun to think about all-digital television. By the end of 1983, the first digital TV sets were rolling off the assembly line at ITT's West German TV plant, and 18 TV-set manufacturers worldwide had made commitments to buy the ITT chips.

I first had the opportunity to observe and operate a working prototype of ITT's Digivision set in a back room at the 1981 version of Berlin's electronics show. The picture was excellent —but we're accustomed to excellent pictures today, particularly at trade shows. What made this set unusual were the tricks it could be taught.

Although the European color system produces fine, consistent pictures, it has one serious flaw: Tied to Europe's 50-hertz AC power, it has a 50-field-per-second (25-frame) rate of picture change, compared with 60 (or 30 frames) in the U.S.

This causes a perceptible flicker, as any American who has traveled in Europe has probably noticed. But the picture on the prototype Digivision was smooth and steady—far steadier than any movie I had ever seen. How come? Digivision had been programmed to add 25 more fields, or half-pictures, between the existing ones.

Also, the remote control had an intriguing new button labeled FREEZE. I pressed it, and the picture stood still: No, this wasn't a tape but a live broadcast. I pressed it again, and the action resumed.

These effects aren't inherent in digital TV, I learned, but are among the perhaps hundreds of special features that can eventually be added at minimal cost, either through the use of special complementary chips or by reprogramming the existing chips.

This fascinating property, added to the fact that, potentially, it will cost no more to produce than a conventional analog TV set—and eventually far less than a comparable model

Continued

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"Next step: a TV on a single chip"

—has caused such manufacturers as General Electric and Zenith in the United States; Panasonic, Sanyo, Sharp, Sony, and Toshiba in Japan; and Blaupunkt and Grundig in Europe to schedule production of digital sets within the next year or two.

Digivision sets of ITT's own brands —SEL and Graetz—are already on the market in West Germany, and the semiconductor manufacturer says it will produce enough chips in 1984 for its customers to make two million sets. In the United States, it's unlikely that any digital sets will be seen before late 1984, with substantial numbers not available before 1985.

Among the unseen advantages of digital sets is simplicity of production. Alignment of tuners is virtually automatic through the internal computers, and picture-tube-beam convergence and pincushion correction, which help ensure sharp, undistorted images, are accomplished by automatic or semiautomatic processing of the video signal rather than adjustment of the tube's circuits. "Our aim," Micic told me, "is zero internal adjustments."

A long-term benefit to the viewer is that these automatic adjustments are continuous throughout the life of the set. A sensor constantly monitors the picture, and the TV's internal microprocessor adjusts the set to compensate for picture-tube aging and other changes throughout its life, maintaining a top-performance picture as long as the tube is working. And there is little or no aging of other components.

When the set is ailing, the service technician can often perform repairs without even opening up the back, by use of a new $150 tool designed specifically for digital TV. It's called a service computer, and it looks like a large calculator with a liquid-crystal-display readout. It hooks into the bus-connection jack at the back of the set and corrects most problems by programming the chips. It can make such corrections as picture height, positioning, anti-keystoning (preventing trapezoid-shape pictures), vertical linearity, color drive, and contrast.

But these advantages are only the beginning. Before considering the true potential of Digivision, let's take a look at the fundamentals of these remarkable sets.

Unlike conventional TV sets, which may have some digital components such as key-pad random-access tuning and vertical-hold circuits, Digivision accomplishes all video- and audio-signal processing in digital form. The incoming signal is converted from continuous-analog form into digital information of the type normally processed by computers—rapid pulses that are either on or off, with no variations in between.

These pulses are impervious, of course, to any analog noise developed within the set, thereby (at least theoretically) providing as clean a signal coming out as the one that went in. Just before the final audio- and visual-amplification stages, the output is reconverted to an analog signal, the form required for the set's needed analog devices—picture tube and loudspeaker.

Five-chip system

The first TV design to fully use VLSI, Digivision is based on five basic chips. The heart and nerve center of the system is the central-control-unit, or CCU, chip. It is an eight-bit microcomputer whose functions include—among others—receiving and decoding orders from the infrared remote control, tuning, band-switching (UHF or VHF), storage of alignment information during production, and control of digital-signal processors for video, audio, and deflection.

The other basic VLSI chips are:

- The video codec (coder-decoder), which converts the video signal from analog to digital, transforms the signal to its basic red, green, and blue (RGB) components, and performs other functions.
- The video-processor unit, which performs all color-signal processing and picture-correction functions.
- The deflection processor, which controls such functions as synchronization-pulse separations, vertical synchronization, and generation of the proper wave forms for Digivision's picture tube.
- The audio-processor unit, which performs all audio functions, including analog-to-digital conversion, unscrambling any stereo signals, volume and loudness controls, bass and treble, and pseudo-stereo effects.

The five basic chips perform functions that would require at least 300,000 transistors in a discrete-component analog set. In addition, at least two peripheral chips are required, the principal one being a clock generator, which generates the exact frequencies required for each of the three leading color-TV standards in

Continued



Remote control for Matsushita's 19-inch, picture-within-a-picture digital television set controls 61 different functions but can handle more than 2,000.

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Ultimate TV

the world—or all three. The other is a power amplifier.

As an example of inherent functions that can be accomplished by its built-in programming, there's the audio chip. In addition to performing all the functions of a sophisticated multi-component sound system, it analyzes the incoming signal and determines whether it's in mono, stereo, or two-channel bilingual. It automatically processes these signals in the proper way. If the signal is mono, it can convert audio, on demand, to a pseudo-stereo effect.

By the same token, being a digital system, the audio chip can directly accept the output of a digital CD disc [PS, Nov. '83], a digital tape recorder, and digital radio broadcasts (soon to be available on an experimental basis in Europe). In fact ITT is offering the chip by itself as a complete digital-audio system, which also includes automatic program sequencing of discs and tapes.

The adaptability of the video chips is almost as broad as the imagination. Some Digivision sets designed for the European and Middle Eastern markets will, through the magic of programming, be able to decode three different color-signal standards using a single color-processing VLSI chip.

Most TV manufacturers are still very secretive, for competitive reasons, about the features they'll incorporate in their digital sets, but a couple of them have given preview peeks.

Resolution revolution

Sony, for example, in both Japan and Berlin, gave demonstrations of what it considers one of the most compelling aspects of the capability of digital TV. I saw a developmental version of a new 30-inch television monitor-receiver (using a giant picture tube, not projection) that generated a high-resolution picture from a standard incoming 525-line broadcast.

Using its own proprietary developments, in addition to some of the ITT chips, the breathtaking picture Sony showed us had a photo-sharp image made up of 1,050 horizontal lines—double the normal number. Sony's picture system does away with the normal interlacing of lines (originally developed to prevent flicker) and displays 60 complete frames, each composed of 1,050 lines, per second in place of the normal 60 fields of 262 lines per second now used. (A field is one-half the lines in a 1/30-second, 525-line picture frame.)

The extra 525 lines in each frame weren't mere repetitions of previous lines but newly generated lines based on the average of the previous and following ones. With the development of more than 1,000 lines of vertical resolution, Sony also increased the horizontal resolution—detail carried by each scan line—to 630 lines (through a red-green-blue computer-type input and a higher-resolution picture tube).

Among other features of Sony's digital set is a dynamic comb-filter system that compares three scanning lines, rather than the usual two, to further increase the resolution and improve picture detail. Sony also added a proprietary "vertical-sharpness" circuit. Its system separates the luminance (brightness) and chrominance (color) signals, processing them separately to eliminate mutual interference and spillover of color into the brightness signal. Sony's high-resolution set isn't due for a couple of years, but the company says that some of its features could show up in models introduced during 1984.

The unreadiness of Sony's TV set was betrayed by the conditions under which I saw it—resting on a large table with a plywood skirt reaching

all the way to the floor. In answer to my question, Sony engineers readily admitted that the enclosed space under the table was "full of electronics" —circuitry that eventually will be reduced to VLSI chips no bigger than a match head.

Panasonic has a different notion of the priority features for digital TV. At the Berlin show it demonstrated a digital monitor TV with a fascinating frame-storage feature, and its engineers insisted to the dubious trade and technical reporters who witnessed the demonstration (myself included) that it would be on the market in 1984. But several months later, Panasonic executives told me that it would be at least 1985 before this advanced frame-storage feature would be available to consumers.

The unique feature of the Panasonic set is its ability to display two color pictures at the same time—the picture-within-a-picture phenomenon that has been available in the past in some analog sets at extra cost but with the second picture in black and white.

Panasonic's 19-inch color set has three video inputs and two RGB inputs for devices such as computers, in addition to all the trappings of a high-end, remote-control TV set. With the hand-held remote-control unit, the user can display the picture from any of the video or RGB sources—from a VCR, videodisc player, computer, or whatever—in a five-inch image superimposed in any corner of the bigger picture. At will, the operator can reverse the pictures, as described earlier. In addition to its use for video-program sources, the Panasonic picture-within-a-picture TV could be employed for monitoring the kids' room while watching TV, or it could be used for security purposes.

Reading the tube

One of the first peripheral chips offered by ITT is a low-cost circuit for adaptation to teletext reception. Because teletext is a digital service, its signal is easily fed directly into the set's computer circuitry. ITT says that adding teletext to a digital set will cost manufacturers about $12, or about 10 percent of the cost of building teletext into a conventional set.

Digital TV can make teletext more useful, as well. Once again, at the Berlin show, I witnessed a unique demonstration of one of ITT's ideas: automatically programming a videocassette recorder from the program listings carried on German teletext. A developmental set on display used a remote control with added features that may eventually become common with digital TV: an up-down, left-right cursor control and a button marked ENTER.

To program a VCR, you call up the network- and cable-program listings by dialing the proper teletext page with the remote control and then storing the listings on the screen in the TV's memory. You then move the on-screen cursor—a small luminous rectangle —across the program listings, pushing the EXECUTE button when the cursor comes to a program you want to record. When you're finished programming the VCR, the screen displays a list of taping choices in sequential order, listing date, starting time, ending time, station call letters, channel, and name of program. It gives a warning if you've selected an impossible combination, such as two programs that overlap in time.

So far, I haven't even mentioned what could be the early big attraction of digital TV in the United States. As noted, Digivision pictures are virtually indistinguishable from that of any good color set. But this implies that both sets are operating under ideal conditions, both processing a high-grade signal.

But who really gets a high-grade

Continued





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Ultimate TV

signal? Broadcast and cable reception in the United States is often plagued by electrical, co-channel, and adjacent-channel interference, and by television's biggest reception problem—ghosts. Added digital chips can identify these troubles and cancel them on the spot. Although ghost-identification-and-exorcising circuits have been under design for some time, they're digital devices, and the cost of including them in analog sets would be prohibitive. But in digital sets, it's a snap.

When will the ubiquitous TV ghost be but a phantom of the past? I can only guess, but certainly by 1986 (or possibly before) we should be able to buy digital sets with built-in ghost and interference eliminators, and possibly even plug-in add-ons to accomplish the same purpose for presently available digital-component-TV outfits.

Gizmos and gimmicks

Strictly in the trick-and-gimmick department, once a low-cost digital frame- or field-storage chip becomes available, you can expect to see many remote controls equipped with a zoom feature—a more versatile one than the primitive attempts of the past (some Zenith models enlarge the center portion of a TV picture on demand). The viewer may be able to enlarge any segment of the picture, in several different degrees of enlargement, without the coarse line structure of early zoom systems.

Another realizable gizmo is the paint-a-picture feature, making it possible to change any colors on the screen at will—letting the kids have fun changing a normal wildlife scene to, say, a pink-and-green zebra nibbling chartreuse grass. This feature could give birth to a whole generation of videodisc or video-cassette coloring books for filling in the spaces by number or imagination.

Although ITT is far ahead of its competitors in developing chips for all-digital television, others are rushing to catch up and to provide at least partial digitization of the TV receiver in the next few years. But in less than two years, Micic expects to be offering set manufacturers samples of a digital-TV system requiring only three, instead of five, basic VLSI chips. After that, perhaps within five years, the next step would be a TV set on a single chip.

Asked about some TV-set engineers' complaints that the groupings of functions within the five chips may not be ideal, Micic laughed his hearty laugh and said: "When we get to a set on one chip, the functional partitioning will be academic." And al-

though competitive semiconductor houses are racing to catch up, some industry observers believe Digivision will be down to one chip before some of the others can produce a TV set with five.

With the advent of the single-chip set or possibly before—maybe as soon as 1986 or 1987—ITT expects digital sets to be cheaper than analog ones, even at the "low ends" of TV lines. At the outset, Micic explained to me, his goal is to be "less expensive for the same complexity." He added: "Being digital isn't our sole target—we also want to be cheaper."

Most American TV engineers take this with a grain of salt, and although they don't doubt that digital sets someday will be cheaper than analog ones, they say it won't be true in the initial stages. "If we can break even without a cost increase initially, we'll be happy," said Zenith's Robert Hanson, executive vice-president for consumer products, who views the transition to digital circuits as a step of equal significance to the development of the first solid-state TV set.

When I said earlier that the new digital circuits constituted a sophisticated computer disguised as a TV set, I wasn't speaking rhetorically. The very nature of its insides will make the digital television the ideal friendly terminal for home-computer systems. Right from the start the digital TV's computer memory will probably augment that of the home computer, increasing its power.

In fact, with the addition of perhaps one chip, the digital TV will become an all-purpose home computer, requiring only the addition of a keyboard and programming medium such as a disk or cassette drive. The keyboard could also serve as the wireless remote terminal for the TV set. In the not-too-distant future—perhaps starting as early as five or six years from now—the home computer, the TV set, the home stereo system, and who knows what else will blend and merge and become a single instrument.

Micic, who has 60 patent applications for his digital-TV system, shrugs off sweeping statements about his "new" technology. "The problem is not technology," he insisted, "but adapting computer technology to television sets. An IBM 360 can produce a TV picture, but it can't do it economically. Our development isn't pure technology but a system concept."

That's a mere preview of just some of the potential of the most exciting new development in television-set design, as within the next two years we watch the smart computer begin to replace the dumb television set. PS

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New washer's an efficiency champ

The carton containing the new White-Westinghouse LT250E clothes washer looked ordinary enough when it was delivered to my house, but it turned out to be a real surprise package.

The first surprise was on the yellow energy-guide label stuck to the side of the new front-loading washer. According to the label, the washer with the lowest energy consumption—this one—would cost $37 a year to operate; the washer with the highest energy consumption under the same conditions (tested according to Department of Energy standards) would cost $150 a year.

The second surprise was the washer's size. By redesigning the suspension system, the engineers were able to fit a full-size, 2.3-cubic-foot basket (that's more than twice the size of most compacts) into a cabinet only a little larger than a typical compact.

And few compacts use less water than this machine. Unless you use strictly cold water for washing and rinsing, a washer's water consumption also influences its energy consumption.

I measured the hot-water usage by putting a water-consumption meter between the new washer and the storage tank for my heat-pump water heater [PS, May '82]. With the washer's controls set for warm wash and warm rinse, it used only 10.5 gallons of hot water for a large load. Other machines I've tested—all top loaders—consumed about 32 gallons under similar conditions. In many areas the *total* amount of water consumed is also important. The LT250E used only 21 gallons on the small-load setting and up to 32 gallons on the large-load setting. (Other washers I've tested used more than 60 gallons.)

Front-loading washers have traditionally used less water than top loaders, but some design changes have reduced the volume even further in the new LT250E. The tub is no longer placed at an angle but is vertical within the machine. And the baffles in the basket take maximum advantage of turbulence and drop.

The LT250E can snug under a kitchen counter, or the washer and mating dryer can be stacked. Both washer and dryer are quiet, and I judged the washer's cleaning ability to be excellent. Suggested list price is $640 (but it's bound to be discounted). Suggested price of the matching electric dryer is $410, and the gas dryer (the only stackable gas dryer available) is $450.—*Evan Powell*



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And its ability to spray into crevices makes intricate jobs, such as louvered doors and wrought iron railings, easy to handle as well.

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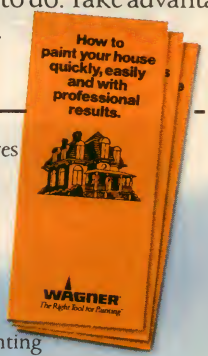
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Alfa Romeo's Japanese connection



There's a lot of talk these days about General Motors' plan to produce small economy cars with Isuzu, Suzuki, and Toyota. But the U.S. maker is not the only one developing joint ventures with the Japanese, who lead the world in low-cost auto production.

Alfa Romeo and Nissan (Datsun) are now jointly producing a front-drive economy car called the Arna (Alfa Romeo Nissan Automobile). Nissan produces most of the body and some of the mechanical parts, including the rear suspension, rear brakes, and rear-seat structure. Alfa produces the pancake engine, five-speed manual transaxle, some body parts, and the balance of the mechanical parts, and assembles the car at its Pratola Serra (Avellino) and Pomigliano d'Arco (Naples) plants.

Although the Arna is not available in the U.S., I recently had an opportunity to test-drive a four-door hatchback version.

My initial reaction to the car's styling was a barely stifled yawn. At first it seemed to blend into the New York city traffic flow with the consummate ease of any Japanese econo-box. But later, other drivers seemed to take notice. In fact the longer I had the Arna, the more people seemed to point and roll down car windows to ask whether Alfa was selling the car here.

Part of the attention may have been due to the European-spec, non-sealed-beam headlights. These are an impressive pair of halogen units that concentrate a powerful beam of light with a sharply defined cutoff point.

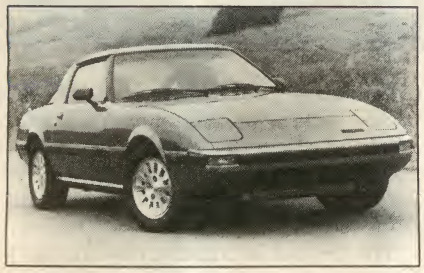
Arna's 1.18-liter (72.3-cu.-in.) flat four's power and drivability were much less impressive. The engine was slow to warm up on cold mornings and was extremely balky, even after I had pushed in the manual choke when the engine reached operating temperature. My first thought was to blame the single down-draft Dellorto carburetor, but perhaps the car wasn't in proper tune. Only the most artful attention to throttle, shift points, and clutch provided just-adequate performance. Over a two-week test period of almost exclusively heavy stop-and-go traffic, I averaged just over 25 mpg driving fairly aggressively.

The Arna's five-speed transaxle was an only slightly better performer. Although all of the ratios seemed well chosen to match the engine's power curve, first gear was often difficult to engage, especially in slow-moving traffic.

Handling and braking were the little hatchback's strong points. Lane changes, heavy city traffic, and twisting roads were a pleasure. The Arna's rack-and-pinion steering responded surely and quickly, and even the most mundane grocery-getting chores were fun. Though not power-assisted, the brakes were quite responsive. Even the lightest stab at the pedal would reduce speed with a seat-belt-tightening quickness.

The Arna may help Alfa Romeo become solvent, but, unfortunately, this vehicle lacks much of the performance and all of the romance of Alfa's older vehicles.—*Jack Keebler*

Rapid rotary has tuned induction



MONTEREY, CALIF. Heat waves shimmered off the blacktop as I drifted through the first turn at Laguna Seca Raceway. The blurry end of the raceway's straight was closing fast, with my car's speedometer needle floating somewhere above 100 mph. I tapped the brakes to scrub some speed, stabbed the throttle to bring the engine revs up, and dropped from fifth to third gear. Back on the gas, the car settled into a slow four-wheel drift up the hill to within inches of the right edge of the track. Lap after lap, I made this corner at the same high speeds, using the same late braking points. Each time Mazda's new RX-7 GSL-SE responded with flawless consistency.

Displacing just 1,308 cubic centimeters (80 cu. in.), the GSL-SE's fuel-injection-equipped 13B rotary develops 135 hp at 6,000 rpm and 133 ft.-lbs. of torque at just 2,750 rpm. Compare that with the 101 hp at 6,000 rpm and 107 ft.-lbs. of torque developed by the 1,146-cc (70-cu.-in.) 12A rotary in the S, GS, and GSL versions of the RX-7.

Three new systems make the 13B engine a more powerful and efficient engine than its predecessor, Mazda says. The first is Mazda's DEI (dynamic-effect intake), which provides an effect similar to supercharging by using air-pressure waves in the intake manifold to force more air into the combustion chamber. According to Mazda, rotaries have a clear advantage over piston engines when it comes to intake-manifold tuning. The second modification has been dubbed 6PI (six-port induction). Unlike the standard engine, with only two ports per rotor, this new 13B has an additional "power" port. It's controlled by exhaust pressure and opens only when power is needed at high engine speeds. Finally, to ensure smooth engine performance (proper fuel delivery) despite the long runners and specially tuned intake manifold, Mazda put in electronic fuel injection.

The extra power makes it easy to throttle-steer the RX-7's already-well-tuned chassis through right-angle turns or long sweeping curves with one-handed ease. More important, it makes the RX-7 a pleasant car to drive around town or in heavy traffic.

To get the additional power to the ground, Mazda shod the RX-7 with Pirelli P6 205/60VR tires. And to further enhance the car's grip and responsiveness, the body-attachment points for the rear suspension's control arms were lowered by 0.8 inch and an optional speed-sensing, variable-rate power-steering system was added.

In the past I've found the RX-7's stopping ability to be the one weak point in an otherwise excellent vehicle. Now Mazda has installed larger ventilated brakes on all four corners and a bigger master cylinder. Even after several scorching laps over Laguna Seca's serpentine course, there wasn't a trace of fade or increased effort. EPA numbers for the sleek coupe are 18 mpg in the city and 29 on the highway. Mazda's suggested base retail for the GSL-SE is $15,095.—*Jack Keebler*

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Permafrost hothouse



Garden-fresh tomatoes at −50 degrees F? For the 600 residents of McGrath, Alaska, year-round fresh vegetables have become an affordable reality since the completion last spring of a 3,200-sq.-ft. commercial greenhouse. The greenhouse is warmed by waste energy from electrical generators at a Federal Aviation Administration facility a half mile away.

The McGrath Greenhouse Project, operated by McGrath Light and Power, Inc., is the first of its kind in bush Alaska. To a community that is inaccessible by road, it brings an important measure of self sufficiency while also saving energy.

Heat is recovered from the generators when glycol coolant exceeds 190 degrees F. Plate-type heat exchangers transfer the energy to circulating water, which is then pumped to the greenhouse through conduits buried two feet below the soil surface. The hot water is distributed to four distinct zones within the greenhouse through four-inch pipes.

The building is well insulated: Two-inch Styrofoam is built into its base, and its exterior walls are double layers of Plexiglas with a ¾-inch air space. Even when outside temperatures drop below −60 degrees F, the soil temperature stays between 80 and 82 degrees, the air temperature between 72 and 78 degrees, and the water used for irrigation at a constant 70 degrees. The waste-heat system is used only in winter; the northern community's 21 hours a day of solar energy keep the structure amply warm in summer.

Special construction techniques were used to overcome the problems caused by permafrost. Ten feet below the surface and extending to the bedrock in many places, the ground is permanently frozen. Following precautions used in building the trans-Alaska oil pipeline, a 12-inch bed of compacted gravel was laid under the greenhouse at a depth of seven feet. This procedure facilitates drainage and prevents uneven melting from causing frost heaves.

The project is managed by Alaska's former state horticulturist, 72-year-old Harold Pillsbury. "It was essential to find someone familiar with growing conditions in Alaska," says Pillsbury, who has operated greenhouses as far north as Fairbanks.

Pillsbury and his staff tend more than 400 tomato plants, which yield about 300 pounds of fruit each week. The equivalent of an acre of strawberries is grown hydroponically in specially installed tubing, as are sizable amounts of cucumbers, peppers, and other vegetables.—*Samuel Hammer*



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Voyager has room for two or five passengers or, would you believe, an option for seven. Voyager is a front-wheel drive wagon with rack and pinion steering. It handles like a car in town and over the road, parks just as simply and easily fits in your garage. Altogether, The New Chrysler Technology has created versatility GM, Ford and most of the imports haven't matched.

Would you believe the mileage? 37 EST. HWY. 24 EPA EST. MPG.*

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It's 3 feet shorter than a big wagon. Garaging is simple.



With rack and pinion steering, it parks like magic.



Voyager is designed for easy, graceful entrances and exits.



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With Voyager LE, as shown, you travel in comfort for $10,887,† and that includes 7-passenger seating, automatic transmission, roof rack, highback buckets and wire wheel covers. Voyager prices start at $8,669† complete with 5-speed manual, power brakes, power steering, full carpeting, electronically tuned radio and plenty more. Plymouth Voyager. The Magic Wagon. You've got to drive it to believe it. Buckle up for safety.

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The WHAT'S NEW magazine
Popular Science

What's News

A remarkable thing has happened. After decades of producing planes that looked pretty much like those that came before them, the aviation industry has suddenly burst out of the old pattern and is now busy building the first generation of planes using such advanced features as canards, winglets, rear propulsion, and composite structures. And these new planes not only *are* different, they *look* different.

The picture on the cover proves that. It shows the Beech Starship 1, one of the most innovative of the new planes. All of the new planes are business aircraft. But clearly it won't be long before these new design trends spread through the entire industry. Burt Rutan has been building small planes using these advanced design features for some time; in fact, his innovative work [PS, Nov. '78, Aug. '81, May '82] is largely responsible for what is now happening. The next step is for the principles to be applied to airliner designs. That's happening, too; NASA has released early news of work in this direction.

Solar-pond record

Contracts have been signed for the construction of the largest solar pond yet. It will be built in Danby Lake —currently a dry lake bed—in San Bernardino County about 175 miles east of Los Angeles.

The agreement between Southern California Edison and Ormat Turbines, Inc., an Israeli firm considered the world's leading expert on solar ponds, calls for a plant with 48 megawatts of generating capacity by 1987. It will cost about $100 million.

A solar pond [PS, April '81] may be one of the most efficient forms of solar collector yet developed. It consists of a body of relatively shallow water (the California installation will be 15 to 20 feet deep) with a layer of saline water on the bottom and a less saline layer on top. When the sun shines on a normal body of water, heat absorbed by deep layers causes the water on the bottom to rise to the surface where it quickly loses its heat. In a solar pond, though, the lower layers are saltier and thus heavier. They don't rise when heated, so the heat accumulates. The temperature can get as hot as 200 degrees F. Ormat has developed a Rankine-cycle turbine that can operate at that temperature and drive an electrical generator.

The first 12-megawatt unit should go into operation in 1985. Ultimately the completed plant could supply peak power for 30,000 customers.

Passive solar heats up

Somewhere between three and five percent of new houses being built these days incorporate passive solar features in their design. That may not sound like much, but it's a big jump when you consider that that is up from essentially zero just five years ago. And some experts are now predicting that a walloping 50 percent of new homes will be passive solar by the late 1980s—just five years from now.

Perhaps the biggest change: Such homes are no longer confined to the sunny Southwest. From Colorado to Massachusetts, from Alabama to Minnesota, passive-solar homes are springing up. The reason: They save money. For example, a Kingsport, Tenn., builder says that although the houses cost up to 10 percent more than conventional houses, they cut heating costs by somewhere between 50 and 80 percent and pay back the investment in five years or less. And as energy consultant Amory B. Lovins puts it, "They're so common-sensical."

Bubble memories

The bubble memory ["Magnetic Bubbles," PS, Oct. '79] has many advantages. It jams a lot of memory into a small volume, for example, and it doesn't lose its information when the power goes off. The only reason it has not already come into wide use is that it is expensive.

But as in all other areas of electronics, the price is coming down. And with the lower price comes more-widespread use. The Sharp PC-5000 computer, for example, uses bubble memory to store 256 kilobytes of information. Now, another use. Hicomp Computer Corp. has introduced 256K and 512K bubble-memory expansion cards for the IBM PC. They cost approximately $1,000 and $1,500, which is about twice the cost of a floppy-disk drive, which could store the same amount of material. But they can store and retrieve material more rapidly than the disk drives and would share the quality of not losing the material when the power is turned off. They are also not mechanical devices subject to shock, wear, and misalignment.

As prices continue to come down, the bubble memory will obviously become important in the truly portable lap-sized or briefcase-sized computers. Designing disk drives small enough and rugged enough for such machines is still a challenge. Building in the storage capacity of a couple of disk drives and doing it all on a couple of rugged chips obviously has its attractions.

Index available

I get letters from readers every week asking why we don't publish an index of PS articles. The answer is that we do—although that must be one of the best-kept secrets of the age. Annual indexes have been available since 1972, and all years through 1983 are available. They're $1.75 each. But if you buy five or more, the price falls to $1 each. Write Popular Science Indexes, 380 Madison Ave., New York, N.Y. 10017.



Editor-in-Chief

Hot new shapes

—passenger planes that will revolutionize aviation

By JIM SCHEFTER
Illustrations by Russell von Sauers

Sweeping through the sky over Love Field in Dallas, Texas, Starship 1 caught every eye in the crowd below as it Dutch-rolled through a precise demonstration of maneuverability. Its tandem wings and canted tipsails—tail-like winglets rising sharply from the main wing—gave the plane the look of a novel spacecraft.

Moments later it was gone, climbing north for a quick flight back to the suburban airport where Beech Aircraft Corp. shielded its incredible airplane from close-up viewers. On the ground in Dallas, awestruck watchers at the National Business Aircraft Assn. annual gathering knew they had just seen the future of their industry.

After nearly 40 years of more-of-the-

Continued



The GP-180 (below) has three lifting surfaces. Its nose-mounted forward wing provides extra lift while helping to trim the plane with flaps that move along with main wing flaps. Two 700-hp fanjet engines are pulled in close to the main wing's center line to eliminate drag-causing slipstream across the wing. A T-tail horizontal stabilizer and elevator provide added lift as well as control. Starship 1 (right) has a long, finely tapered nose. A variable-geometry forward wing moves forward and aft simultaneously with the main-wing flaps. The swept main wings flare into a delta shape then taper into a slim airfoil with tall tipsails. Rudders at their trailing edges give directional control. Twin 1,000-hp fanjets are mounted on the delta wing to reduce cabin noise.



The fantasy planes of yesterday are the executive transports of tomorrow. Inspired by the designs of Burt Rutan, companies such as Beech Aircraft and Gates Learjet have developed exotic-looking private planes. Canard wings, wing-tip winglets, and pusher props—features once flaunted only by radical high-performance, one-seater home-builts—are standard issue for the new multi-passenger business planes. And tomorrow's commercial jets may adopt many of these design elements.



same aircraft design, general aviation suddenly is breaking the mold and racing into that future with new planes that challenge traditional thinking. A key factor in the daring new movement is a single individual—Burt Rutan.

His pioneering work in designing high-performance aircraft that use canards and pusher engines has been the subject of several PS articles [PS, Nov. '78, Aug. '81, May '82]. Now the influence of his aerodynamic expertise and the designs he perfected is spreading.

Four companies—Beech Aircraft, Avtek, OMAC, and Gates Learjet—are in the forefront of the trend. Each has developed a high-technology aircraft that promises to mate docile, one-pilot handling with high cruise speed, long range, and low fuel consumption. The planes share unusual design elements:

- Turbine engines and propellers mounted at the rear.
- Wings behind the cabin.
- Canards, or forward wings, with movable surfaces to control pitch.

Other general-aviation aircraft manufacturers are not far behind. Both Cessna and Piper are working on still-secret ships that fall into the advanced category. Meanwhile, looking toward the next decade, NASA is designing a four-engine jet transport with many of the same features.





The Rutan revolution

"Burt Rutan has forced people to look at canards as an acceptable design," said Dennis Riddle, who heads the NASA project at Ames Research Center in Mountain View, Calif. "Canards had gotten a bad name because of potential stability problems. But now we've learned more about their aerodynamics."

In fact it was to Rutan that Beech turned for help in designing its Starship 1. "We wanted the guru of canards on our team," said Beech president Linden Blue. (Rutan is under a gag restriction from Beech. Only Blue would discuss Starship 1.)

The craft makes extensive use of composites in the airframe and skin, another technology in which Rutan excels. His company, Scaled Composites, Inc., in Mojave, Calif., built the 85-percent-scale prototype that Beech is using for initial flight testing.

With the Rutan-built prototype, Beech has a flying wind-tunnel model that gives it actual flight-condition data and shortens the development cycle. The aircraft had more than 170 hours of flight time by late January.

Beech put nearly five years into Starship 1 research and development before unveiling the aircraft in Dallas. From the beginning Beech set its sights high. "We wanted cabin amenities, more speed and performance, and the engine aft for noise reduction," Blue said. "All that drove us in the direction of canard aircraft.

"But the FAA doesn't have the word 'canard' in its nomenclature," Blue noted. " 'Forward wing' is more descriptive. It's a lifting surface, with great aerodynamic subtlety."

After intensive computer-aided design and analysis, Beech decided to go with variable geometry—a movable wing—in the canard (see diagram).

"The advantage to variable geometry is that it counteracts the strong pitching moment when you put a flap out on the rear wing," Blue said. "And the forward wing is a much more elegant way to provide lift."

The wing-tip tipsails also display the Rutan influence. They look much like those on Rutan's VariEze [PS, Nov. '78], a one-passenger home-built. The tipsails serve two functions. They increase the effective wingspan while giving the stability normally provided by the vertical tail they replace. Rudders at their trailing edges give directional control.

In flight, the tipsails act like the sail on a boat moving into the wind. Cutting through the wing-tip vortex, they produce a forward-directed force vector that helps reduce drag.

Starship 1's unique design should make it a good short-field aircraft and give it excellent handling characteristics in both slow flight and high-speed cruise, Blue said.

The unique configuration also gives near-jet performance and great fuel economy to a propeller-driven airplane. Fuel consumption will be about seven miles per gallon, according to Blue, less than half of a typical business jet's.

Starship certification and deliveries are planned for late 1985. Its price will be more than $2.7 million.

Composite contender

The revolutionary Beechcraft will have competition in the corporate market. The Avtek Corp. of Camarillo, Calif., expects to roll out and begin test flights of its all-composite Avtek 400 in early summer. The company has its own share of aviation pioneers.

Among them is Dr. Leo Windecker, Avtek's vice-president for research. A



Jet aircraft of the 1990s may have forward wings and upswept winglets as does NASA's research Sky Warrior (top left). Four jet engines blow exhaust across the upper surface of the rear wing to provide more lift. Avtec's slope-nosed pusher aircraft (left) has a steeply raked horizontal stabilizer, upswept winglets, and a stubby forward wing set above and behind the flight deck. It has two 750-hp turbine fanjets. The skin—a thin Nomex honeycomb sandwiched between a blended Kevlar exterior—is stronger than steel. No interior ribs or other support structures are needed. With such lightweight construction, the engines can produce 6,000 lbs. of thrust. This lets the Avtec 400 take off in just 1,250 ft. and climb at 5,400 ft. per minute.

former Du Pont researcher, Windecker developed the Windecker Eagle, the only all-composite airplane ever to receive an FAA airworthiness certificate [PS, Jan. '71].

Bill Taylor, a test pilot whose first-flight credits include the Eagle and OMAC-1 [PS, Dec. '83], sketched out the Avtec 400's configuration in the early 1970s. Al Mooney, another Avtec partner, refined the design. He made his name with the Mooney Mark-20, a high-performance, single-engine craft that's still a favorite of pilots. Paul MacCready, developer of the Gossamer human-powered aircraft [PS, Dec. '78], is the company consultant on lightweight materials. Finally, Avtek's president is Robert Adickes, a retired 747 captain and a financial wizard who helped Bill Lear with early work on the Learjet.

The plane designed by this elite team is as unique in construction as it is in configuration (see diagrams). There is no metal in its airframe or skin; even the propellers are composites. "Our airplane is a composite of composites," Adickes said. "We use all of the fibers."

Graphite composites are used in the 400's structure where extra stiffness is needed. Kevlar and Nomex, the primary composites used, are high-strength polymers. Kevlar has notable advantages for aircraft construction, Windecker said. It has six times the strength of graphite-epoxy composites but is only half as stiff. Nomex provides the stiffness needed in body and wings but is feather-light compared with materials such as graphite.

"With these new materials," Windecker said, "we can design a structure and determine the stiffness, shear strength, and other properties needed, then blend the composites to get a material that meets the specifications." That's just the opposite of long-established procedure, in which engineers must design airframe components to match the properties of materials.

The major benefit is a sharp reduction in weight. To demonstrate, Adickes handed me an aileron and then a flap being readied for the flight-test aircraft. I held them easily in one hand. With conventional aircraft parts, this would be a two-handed chore.

Windecker had calculated that the Avtek 400, from the cockpit to the back of the plane (excluding wings), would weigh just 290 pounds—less than half the weight of a conventional fuselage. When the components were ready, Adickes weighed them.

"I finally caught Doc in a mistake," Adickes said with a laugh. "It weighed 288 pounds. He owes me two pounds."

Another benefit of composite construction is drag reduction and aerodynamic smoothness. Like the Windecker Eagle, the 400 will have no rivets and no seams to disrupt airflow. The skin also will withstand weathering. At a nearby airport Windecker showed me his Eagle. At age 14 the plane is smooth and shiny.

Windecker expects the final aircraft to weigh just 3,100 pounds empty and have a gross weight of 5,500 pounds. That will make it the lightest six-to-nine-passenger aircraft in the world. (See weights of competitive planes in tables with illustrations.)

"The 400 will be a thrifty, comfortable, long-range aircraft," Adickes said. He expects the plane to average about 13.3 miles per gallon of gas —one-quarter the consumption of a standard business jet.

To get initial data, Avtek built and successfully flew several five-foot-wingspan, radio-controlled versions of the 400. These "wind-tunnel-in-the-sky" models performed as the designers had hoped, Adickes said.

Adickes and Windecker expect their craft to receive FAA certification in mid-1985. "Doc is the only person ever to get a composite plane certified," Adickes said, "and almost nothing has changed since the Eagle. If anything, the regulations are now better defined, and this process will be easier."

The Avtek 400 will sell for about $1.5 million, and the company has already taken five-percent deposits for the first 100 planes.

Variations on a theme

Also continuing toward 1985 delivery is the OMAC-1 [PS, Dec. '83], a single-engine pusher with winglets and a forward wing. To control any downward pitch moment, the OMAC design has the elevator and trim tabs on the canard.

OMAC-1 is only slightly larger than the Avtek 400 and will carry six people transcontinental distances at 230 mph. This makes it the slowest of the new designs, but at about $600,000 it's also the least expensive.

The new aircraft that's furthest from production is the GP-180, the Gates Learjet-Piaggio twin-engine pusher, scheduled for first delivery in late 1986. The GP-180's base price will be about $2.7 million.

The craft was designed by the Ital-

[Continued on page 143]

Electronic magic:

new color for old b&w movies

Pink cheeks for Laurel and Hardy? Blond hair for Constance Bennett? Old black-and-white movies may never be the same since a Canadian inventor developed a computerized coloring process.



By EVERETT H. ORTNER

Great stories, great photography, great stars—they're all there in those wonderful old black-and-white movies. So why have so many of them never been shown on TV? No color. Color amounts to only five percent of the graphic information content of a movie, yet without it a movie is dead in the marketplace. That's why Wilson Markle's company, Vidcolor Image, Inc., in Toronto, is busy adding color to such antique films as *Topper* and *Mutiny on the Bounty*—along with the old Laurel and Hardy two-reelers. Markle, who invented the electronic process, calls it "colorization."

Shooting in black and white, either because color technology did not yet exist or because of budget limitations, the original film makers were concerned primarily with tone and contrast in the photography. That leaves the color decisions to Markle's art director: actors' hair color, for example, and makeup, and color schemes for wardrobes and sets.

Markle starts with a fine-grain copy of the original film, which he transfers to one-inch broadcast tape. "That's our master," he says. That in turn is transferred to ¾-inch tape, the working copy, which is "referenced" with time-code numbers "so we can always precisely refer back to the original."

Now the film is broken down into scenes, and a technician working with a computer electronically colors the first frame of each scene. The colorizer palette provides 4,096 increments of color. The black-and-white images provide shape and texture.

A video frame is made up of minute digitized picture elements called pixels—1,024 horizontal and 512 vertical, a total of about 525,000 pixels. Each pixel has a blackness-whiteness value, called luminance.

In the editing room (photo above) the computer examines the movie, comparing each frame with the one that preceded it. If there is no change in the luminance pattern of the pixels, the computer colors a frame identically with the preceding one. If a pixel is different from its corresponding pixel in the preceding frame, indicating movement, the computer must decide what to do. It may, if all the pixels surrounding the different pixel are of the same hue, assign that hue to it. Or it may try to find matching luminance values in the preceding frame and give their hue assignments to the pixel. Or it may tell the operator: "You handle it."

"The difference between successive frames is typically a maximum of five percent," Markle explains. "So 95 percent of the second frame is already colored—because it's unchanged."

When it's all done, says Markle, a former NASA engineer, the result is totally convincing: "*Topper* looks as though it was shot in color." PS



Laurel and Hardy movies are getting new color. Stan Laurel really did have blue eyes and red hair. He also wore green makeup to improve contrast with b&w film.







Old-time film stars Constance Bennett and Cary Grant were photographed in black and white (above) for *Topper*. A colorized version of the movie (right) will appear on TV. Close-up photos below of monitor screen show how b&w picture elements are given individual color values through electronic painting.





PS exclusive:
first look at Detroit's

What's coming from U.S. auto makers for 1985 and later? PS Detroit editor and super-spy Jim Dunne has the answers—and the photos. A sampling: more mini-vans, smaller sporty coupes, more K-car derivatives, and—finally—a replacement for the Volkswagen Rabbit.



Four-door sedan (above), Chevy's replacement for its X-body Citation II, is scheduled for introduction as a 1987 model.



'85 models

By JIM DUNNE



Rabbit replacement: It's called the Golf in Europe, but VW of America hasn't decided on a U.S. nameplate yet. The new model will have a three-in.-longer wheelbase and be six in. longer and two in. wider for more room inside.

For 1985 Detroit is ladling up a full serving of models aimed at buyers who want improved fuel economy as well as those who want more of the old-time pizazz in looks and performance.

Engineering changes are not revolutionary. For the most part, engine and transmission combinations will be carried over. But refinements in gearing and fuel induction will improve both economy and performance. Here are some highlights:

- Tighter outside dimensions are standout features of General Motors' new N-cars (also known as GM20): Oldsmobile Calais, Pontiac Grand Am, and Buick Somerset Regal.
- Chrysler will offer a mid-size-sedan lineup of H-models with Chrysler and Dodge nameplates.
- Chevrolet has the compact Astro M-van ready for fall introduction; later, Ford will counter with its Aerostar van of similar size.
- Mercury went to Europe and brought back the Merkur XR4Ti.
- American Motors has a new Jeep XJ pickup truck.
- Volkswagen will have the first redesigned Rabbit in nine years.

GM's Calais, Grand Am, and Somerset Regal are completely new models, not refinements of past offerings. But they use many of the complicated front-drive power trains of existing models. Originally planned as replacements for the Cutlass Supreme, Grand Prix, and Regal, these small front-wheel-drive coupes will sell alongside the older brands in GM dealerships.

Dissect the Calais, and you have a description of the complete line. Pontiac's 2.5-liter (153-cu.-in.) four-cylinder engine is standard; the three-liter (183-cu.-in.) Buick V6 is available as an option. With a wheelbase of 103.4 inches and an overall length of just over 178 inches, the cars border on being subcompacts. (Compare these dimensions with the 108.1-inch wheelbase and 201.9-inch length of Grand Prix.) Fuel economy should be in the

Continued





GM's sporty coupes: Buick Somerset Regal (opposite page, bottom), Pontiac Grand Am (above left), and Oldsmobile Calais (above right) are close to subcompact in size. Standard power plant is a four-cylinder; a V6 is available.



More mini-vans: Ford and Chevy get in on Chrysler's act. Chevy's Astro (below) debuts in the fall; Ford's Aerostar (right) is set for introduction in early 1985. PS showed an Aerostar "concept" van in the April issue; this photo shows a preproduction vehicle.





If Merkur sounds like a Teutonic name, it should. Built by Ford of Germany and sold under the Sierra nameplate in Europe, Mercury will sell the sporty coupe in the U.S. as the Merkur XR4Ti, reportedly at a premium price.

high-20-mpg range with automatic transmission and should push 30 mpg with a manual.

As a money-saving step the N-cars' rear axle is a solid-bar type, not independent as buyers might expect in a sporty coupe of this type.

Corvette will have a five-liter (305-cu.-in.) V8 engine, replacing the 5.7-liter (350-cu.-in.) V8. The smaller engine is a fuel-injection version of the 305 V8 that has been a Chevy workhorse for more than a decade. Look for performance to remain at today's excellent levels and fuel economy to improve thanks to weight savings.

Chrysler's seemingly endless K-car variations continue in 1985 with the introduction of two new sedans sporting Chrysler and Dodge nameplates. Code named H-models, the new cars will use Chrysler's 2.2-liter (134-cu.-in.) four-cylinder engine and front-drive transmission. Aimed at the mid-size-sedan buyer and featuring aerodynamic styling that is a welcome relief from the K-cars' three-box layout, the new lines will have hatchback bodies instead of traditional trunks.

Jealousy reigns supreme at Chevy and Ford, where officials talk about the mini-vans they will have in 1985 while Chrysler corners a big part of that market right now. The competition is so strong for the mini-van buyer—who now has a choice of three imports as well as the Chrysler-built model [PS car test, May]—that Chevy and Ford took the unprecedented step of releasing details about their vans a year early. The obvious strategy is to distract buyers long enough to get the Chevrolet and Ford vans into the showrooms.

Both of the new vans will be conventional in engineering, with front engines and rear-wheel drive. But four-cylinder engines and optional V6s will make these new models much more fuel stingy than today's full-size vans. Look for city fuel economy in the 20-plus-mpg range. It's interesting to note that the new vans will pull a heavy trailer load: up to 5,000 pounds.

Ford will also make minor changes in the Thunderbird and Cougar and revise the front-end styling of the Escort at a 1985½ unveiling. Thunderbird and Cougar will get "bolder-looking" grilles, and Escort will have a "stronger" front-end appearance that includes aero headlights.

Mercury's ace for 1985 is Merkur, a German import sold as the Sierra in Europe. Available only as a two-door, it will be priced above the Cougar. The full name is a mouthful: Merkur XR4Ti.

Pickup Jeep

Two big projects are under way at American Motors, but only one, a pickup version of the Jeep XJ, will be ready for 1985. It is, to put it simply, a Jeep Cherokee with the body chopped off from the door posts rearward. A pickup box and tailgate complete the transformation.

The other project at AMC is an Americanized version of the Renault R25, a mid-size sedan that will compete with GM's A-cars and Ford's Tempo and Topaz. Recently introduced in Europe, the R25 has front-wheel drive, a four-cylinder engine, and room for five passengers.

Volkswagen's replacement for the Rabbit is a "totally different car, though it looks similar," according to one VW of America executive. "Everything is new," he adds. The exterior shape is basically quite similar to that of the present Rabbit, but body surfaces are highly aerodynamic. The new car has a drag coefficient of 0.34 compared with the Rabbit's 0.42. Aerodynamic improvements include flush vent windows and urethane bumpers that blend in with the body surfaces. These features, plus different transmission gearing and more power, improve fuel economy and boost performance. Two- and four-door models will be built at VW's assembly plant in Westmoreland County, Pa. PS

Ion engines for our mission to Neptune

How will we send spacecraft to planets so distant that chemical rockets can't get them there fast enough and solar panels can't provide power? Teams from Los Alamos and the Jet Propulsion Laboratory propose that heat from a nuclear reactor be converted to electricity to power an engine that spews out mercury ions to move the ship.

By GARY L. BENNETT
Illustration by Walter Hortens

The outer-planetary voyager dashes across the blackness of space, having left the sun behind forever, its once-large orb now shrunk to the size of a bright but unresolved star. The spacecraft is an ungainly structure, looking more like a child's attempt at building a barbell with an Erector set than a scientific mission to Neptune. At one end of the central boom, or astromast, is the payload, dominated by a dish-shape antenna. At the other is a large cone capped by a compact cylinder.

Together the cylinder and cone make up almost one-third of the spacecraft's more-than-28-meter [92-foot] length. Periodically they glow at the extreme-red end of the spectrum. Between the cone and the astromast is a panel of 16 cylinders, each 30 centimeters [11.8 inches] in diameter. Whenever the cone and its cylinder warm up, these cylinders give off a blue light.

Cold, giant Neptune, whose mean distance from the sun is more than 2.79 billion miles, may hold the key to resolving fundamental questions about the early formation of the sun's planets. Among the gas giants it was Neptune and Uranus, not Jupiter and Saturn, that exhibited the initial accumulation of the rocky, icy material of the early solar system.

But before cosmologists and astrophysicists can send their detective gear to Neptune to probe for answers, the scientists and engineers who design the craft must answer more-immediate questions: How do you propel a spacecraft to a planet so distant that, if conventional technology were used, the trip could take more than 20 years? And what will be the source of power in this region of space where the sun's intensity is only one-nine-hundredth of what it is on Earth?

Researchers at the Jet Propulsion Laboratory in Pasadena, Calif., with the help of others at the Los Alamos National Laboratory in New Mexico, have already come up with some likely answers. In a study sponsored by the National Aeronautics and Space Administration and the Department of Energy, they propose that: (1) propulsion for a Neptune mission would come from those glowing blue cylinders—electrically powered mercury-ion engines that would push the craft to Neptune after a launch from the space shuttle; and (2) the power for the engines and the payload would come from a small nuclear reactor—the glowing red cylinder of the outer-planetary voyager. Such a mission could begin in the 1990s.

Dr. Bennett, a physicist, is director of safety and nuclear operations in the Department of Energy's Office of Special Nuclear Projects. This article reflects his own evaluation and not necessarily that of the DOE. He has written a novel, The Star Sailors *(St. Martin's Press, 1980).*

The ion engines

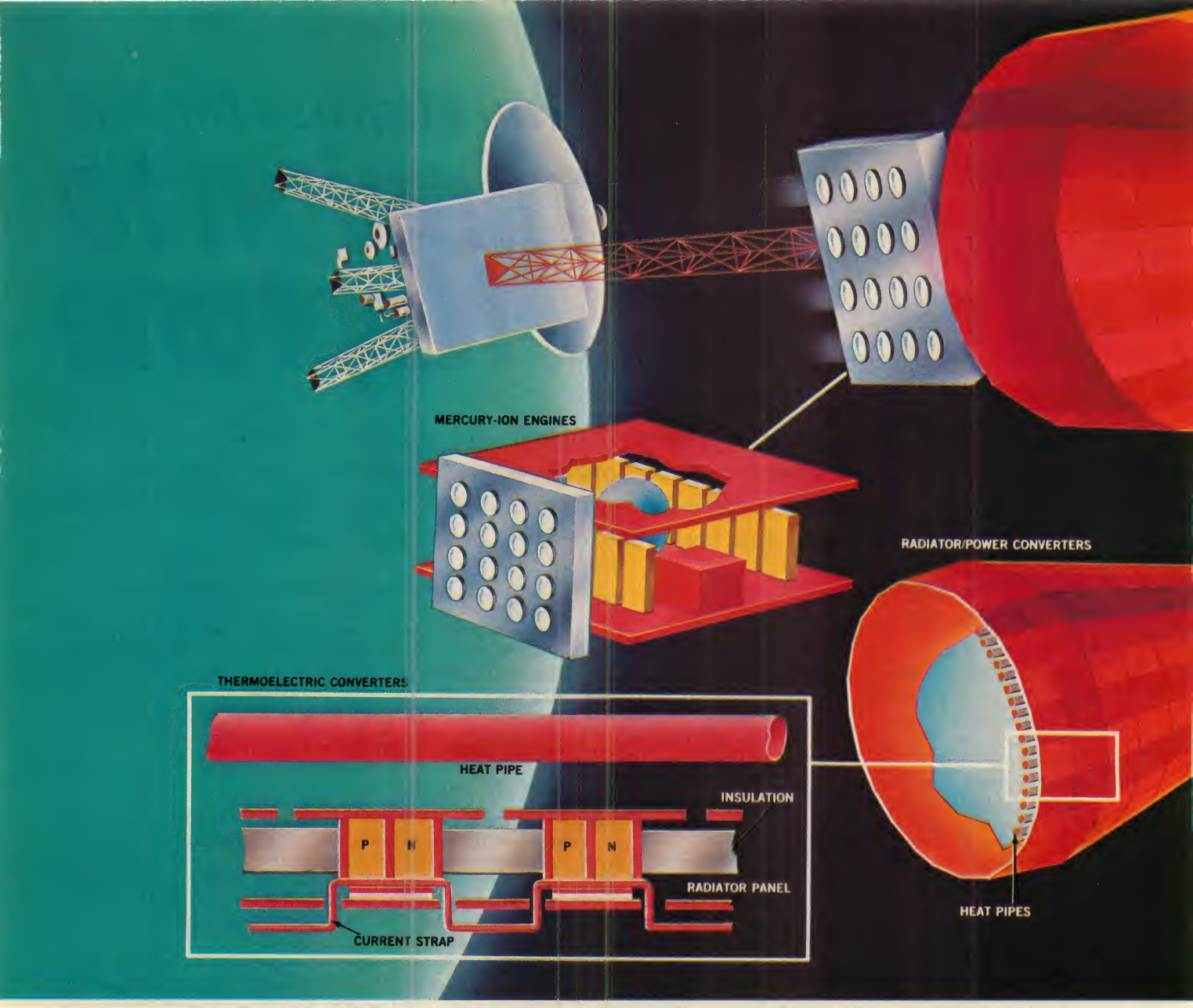
Ion engines exist now as experimental models. Powered by electricity, they work much like the particle accelerators physicists use to study atoms and their nuclei. The blue glow the engines emit comes from mercury atoms that have been ionized inside the thrusters then electrically accelerated out—to impart a minute force or thrust to the spacecraft (see caption).

Work on these electric thrusters began in the early 1960s. At the NASA Lewis Research Center in Cleveland, research scientist Harold R. Kaufman invented what may be the best ion-engine concept, called an electrostatic electron-bombardment thruster. In the JPL proposal, 16 ion engines based on Kaufman's design would be on the spacecraft for a mission to Neptune. They would be mounted in a four-by-four array on a panel next to the cone (where thermal energy from the nuclear reactor is converted to electricity; more on that later). Only 13 ion thrusters would be required for the mission's 50,000 hours of operation; the three extras would provide redundancy. More than 10,000 kilograms (22,000 pounds) of mercury propellant would be carried on the craft.

The longer the ion thrusters operate, the greater the spacecraft's velocity. Still, it is nearly 12 years after launch before the craft approaches Neptune. The planet's internal features remain hidden by the bluish-green atmosphere, made up mostly of hydrogen, helium, and methane. Neptune, nearly 17 times as massive as Earth, has an effective temperature of about 57 K [−357 degrees F]—truly a frozen, inhospitable place. Nevertheless somewhere within the planet is a source of heat, for it remains at about the same temperature as Uranus even though Neptune is one-and-a-half times farther from the sun.

Why not use chemical rockets for a ballistic flight to Neptune as we've done on planetary missions to date? It

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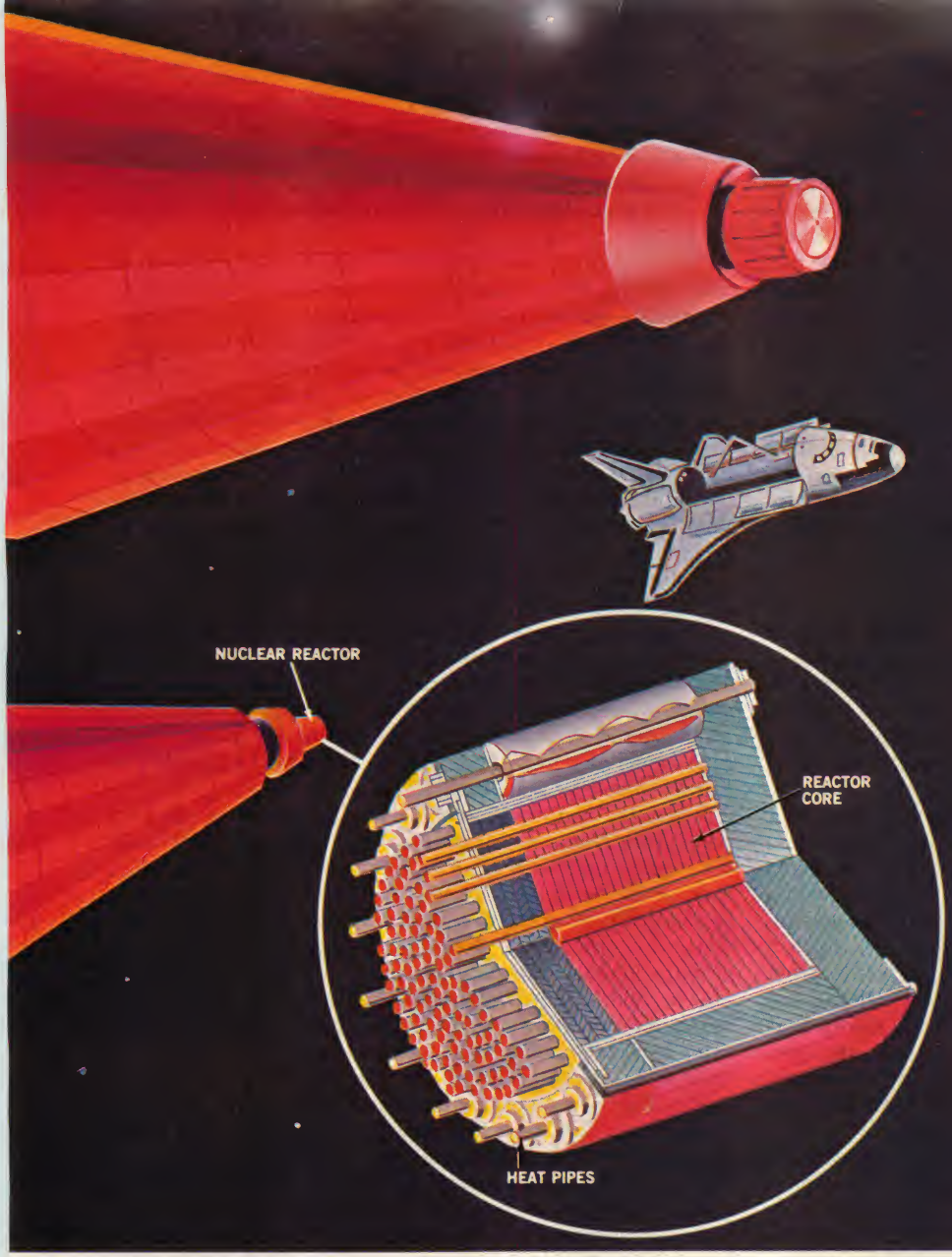


could be done; indeed Voyager 2 is headed for Uranus right now and should reach Neptune in 1989—12 years after launch. But it generally would take much longer than that for such a spacecraft to reach Neptune. Voyager 2, it turns out, is the right mission at the right time: At each stage in its journey it is using the gravity of one planet to boost it, slingshot-style, to the next. This is possible only because of a fortuitous—and rare—alignment of Jupiter, Saturn, Uranus, and Neptune. Without that alignment, using only a Jupiter swingby, a spacecraft for an orbital mission that was propelled by chemical rockets would take more than 20 years to reach Neptune, former NASA associate administrator J. L. Kerrebrock noted in a 1983 report.

Ion thrusters are preferred over chemical rockets for a Neptune mission because they can move larger payloads faster to distant destinations. That's because they use their propellant more efficiently, getting more thrust per pound of propellant. You can see the magnitude of the advantage by comparing the specific impulses of the two. Specific impulse is defined as the amount of propulsive force obtained per pound of propellant consumed per second. The unit of measurement is pound-seconds/pound (usually written as seconds). The best chemical rockets produce between 400 and 500 seconds of specific impulse. With current technology mercury-ion thrusters achieve about 3,000 seconds; the JPL team assumes 5,300 seconds will be possible by the time the mission is launched.

Though it has high specific impulse, the ion engine has low thrust. The three main engines of the space shuttle, for example, have a specific impulse of 456 seconds with a combined thrust of 6.3 million newtons (1.4 million pounds). (One newton of force will accelerate one kilogram of mass through a velocity change of one meter per second every second.) By contrast, each of the mercury-ion engines for the Neptune ship would produce only 0.57 newton (0.13 pound) of thrust. Even if all 16 were operating, they could not lift the spacecraft off the earth (the space shuttle will do that).

Because of the low thrust, it takes a long time for an ion engine to gain an advantage over chemical rockets. But on a mission to reach a planet as distant as Neptune the advantage would be great: Though present-day chemical rockets take off with a mighty flurry of fire and smoke, they soon consume all of their propellant because of their relatively low specific impulse. With that same amount of propellant an ion engine can operate for thousands of hours—a sort of interplanetary version of the race between the tortoise and the hare, with one critical difference: Unlike the tortoise, an ion engine accelerates all the while. The result is a higher final velocity.



Nuclear reactor and radiator/power converters are 29.9 ft. long and 14.8 ft. in diameter at the widest part of the cone (limited by the shuttle's bay). Reactor core contains molybdenum-alloy heat pipes surrounded by fins interleaved with tiny tiles of uranium dioxide. Heat produced by the fission of uranium-235 is transferred to radiator/converters by heat pipes.

Thermoelectric converters turn heat into electricity through a phenomenon called the Seebeck effect: When two junctions of two different metals are at different temperatures, a voltage is established and electrons flow. For the Neptune craft, silicon-germanium semiconductors are used instead of two metals. One side of these converters is exposed to heat from the heat pipes and the other to the radiator panel (a carbon-carbon composite), which keeps that side at a lower temperature. To produce the Seebeck effect in semiconductor materials, P and N legs are doped—the P legs to have a deficiency of electrons (called holes) and the N legs to have an excess of electrons. Thus the legs are analogous to the positive and negative terminals of a battery. Doped in this fashion and with the two sides at different temperatures, a voltage is established, and electrons flow from the hot side to the cold side of the converters. There current straps siphon off electrons, and the excess heat is radiated to space. Current straps join converters so that one failed converter won't open the whole circuit. Current is delivered to the payload and to mercury-ion engines.

Within each engine an electric field accelerates electrons, which bombard the mercury propellant, stripping off electrons and leaving positive mercury ions. A potential difference accelerates them out of the engine, propelling the ship in the opposite direction.

For the Neptune mission the ion engines would have to operate steadily for about 427 days to escape from Earth and go for more than three years to accelerate the ship to Neptune. The total mission would last 13 to 14 years, but for much of the time the engines would be off.

About 150 Earth days before the spacecraft reaches its closest approach to Neptune, an atmospheric probe separates from the payload section and heads for Neptune, continuing the trajectory of the mother ship.

The remainder of the spacecraft—the orbiter—continues its solitary journey for several days as if nothing had changed. Then the giant cone increases in temperature to 800 K [980 degrees F], and soon the ion engines are again glowing blue. Slowly, over a period of 1½ days, the orbiter changes its speed and direction and races toward Triton, Neptune's largest satellite.

The problem of power

Earth-orbiting satellites and planetary missions to date generally have used photovoltaic cells or batteries to power their payloads. But at Neptune, not enough solar energy is available to power even the payload, let alone the payload and the ion engines. The JPL proposal calls for 100 kilowatts; at Neptune, with near-term technology, it would take a solar panel that's 10 times the length of a football field on each side to provide that much power. Chemical batteries capable of providing the energy would weigh several thousand times the 20,000 kilograms (44,000 pounds) of the entire projected craft—and they might not last to the end of the mission.

The most—perhaps the only—practical power source for a Neptune mission (and even more distant space voyages) is nuclear power. Though used less commonly than solar cells, nuclear power is well proven for running the instruments on spacecraft. The Pioneer and Voyager flybys of Jupiter and Saturn, the Viking landings on Mars, and the Apollo lunar scientific packages have used nuclear power sources. But these were small power sources called radioisotope thermoelectric generators, or RTGs. They generate heat from the natural radioactive decay of plutonium-238. The heat is converted to electricity by taking advantage of a natural phenomenon called the Seebeck effect (more on that later).

But RTGs capable of providing 100 kilowatts of power for a Neptune mission would be impractically large—and costly. Thus researchers at Los Alamos began design work in 1979 on a nuclear reactor for the mission. A reactor generates heat through nuclear fission—a controlled chain reaction—as in a nuclear power plant. A reactor can pro-

Continued

vide much more power in a smaller volume than can an RTG. The reactor proposed by Los Alamos would generate heat through the fission of uranium-235 supplied in the form of uranium dioxide. The uranium dioxide would be shaped into tiny tile-shape wafers—29,000 of them—generating a total thermal power of 1,600 kilowatts, which is equivalent to the power of more than 50 home furnaces, in the space occupied by seven one-gallon paint cans.

If the Los Alamos reactor design is flown, it will not be the first reactor in space. The Soviet Union reportedly has flown at least 19, but none has been used for interplanetary exploration. In April 1965 the U.S. launched its first space reactor, a small experimental unit called SNAP-10A. Should the Los Alamos reactor design not be selected for the Neptune mission, planners could consider the technologies developed in the SNAP (Systems for Nuclear Auxiliary Power) program. (The RTG technology was also developed in the SNAP program.)

Heat conversion

Another problem faced by the reactor-design team at Los Alamos was how to convert heat from the reactor to electricity for the ion engines and the rest of the spacecraft. Reactor power systems on Earth use pumps and turbine/alternator systems. But these need maintenance, and their moving parts wear out. The Los Alamos researchers opted for a conversion system with no moving parts.

For this, they borrowed from RTG technology and went back to a basic principle of thermoelectricity discovered in 1826 by the German physicist Thomas Johann Seebeck. Seebeck observed that a voltage could be produced from a temperature difference in the two junctions of two dissimilar-metal strips whose ends had been joined to form a circuit. We now know that the Seebeck effect results from the diffusion of electrons across the junctions of the two metals. Since Seebeck's time, researchers have shown that semiconductor materials (a mixture of silicon and germanium, for example) "doped" by the addition of impurities (such as boron or phosphorus) make more-efficient power converters than metals.

Using the Seebeck effect, the Los Alamos researchers propose to produce electricity on the Neptune mission by heating one side of the silicon-germanium converters (preferably to more than 1,000 degrees C [1,832 degrees F]) with heat from the nuclear reactor while keeping the other side relatively cool (less than 567 degrees C [1,053 degrees F]). Power then could be tapped as needed.

It would take about 220,000 of these small silicon-germanium converters to produce the desired power. They must be sufficiently separated to accommodate their physical dimensions and to allow for radiation of the unused heat to space. This leads to the cone shape behind the reactor and explains why the cone would be warm (and glow red) when the reactor is operating.

Almost five months after the orbiter and probe separate, the orbiter whips past Neptune, sailing about 98,000 kilometers [61,000 miles] above the clouds of frozen argon crystals. At about the same time the probe plunges toward these crystalline clouds at a velocity of about 24 kilometers per second [54,000 mph]. It drops like a fireball into the frigid atmosphere, where it is slowed by parachute to take samples and measurements.

The probe begins beaming its readings to the orbiter for retransmission to Earth. A little more than four hours later these pulses reach Earth, giving the human race data from its first direct sampling of Neptune's atmosphere. By then the probe is finished, its electronic life crushed: It has penetrated to the water-cloud layer where the atmospheric pressure is 100 times that of Earth.

One more key problem faced the nuclear-reactor design team: how to transfer up to 1,600 kilowatts of heat from the reactor to all of the silicon-germanium converters —again without moving parts. In the Los Alamos concept this would be done with 120 heat pipes, each eight meters (26 feet) long and 1.59 centimeters (0.63 inch) in diameter.

The heat pipe, developed by George Grover at Los Alamos in 1963, is an extremely efficient device for transferring heat—about 10,000 times better than silver, the best metal conductor [PS, June '74]. In the Los Alamos design, heat from the reactor would be absorbed by liquid lithium inside each heat pipe, vaporizing the lithium. The hot lithium vapor would flow to the cooler end of the heat pipe (within the cone structure), where it would cool and condense, transferring its latent heat to the nearby silicon-germanium converters. The lithium would flow by capillary action back to the reactor end of the heat pipe to repeat the process. Each heat pipe would be capable of transferring 15 kilowatts at a temperature of about 1,500 K (2,240 degrees F).

Though the probe is finished, the orbiter continues around Neptune, passing within 1,000 kilometers [620 miles] of Triton. The gravitational force exerted by this giant among satellites has captured the orbiter in a highly elongated orbit around Neptune. From the vicinity of Triton, Neptune looms as a cyan-blue sphere 16 times the diameter of Earth's moon as seen from Earth.

When the spacecraft reaches the apoapsis—or farthest point from Neptune—of its orbit, the nuclear reactor and cone warm up and the ion engines emit their bluish glow, raising the periapsis—or closest point to Neptune—of the craft's orbit by about 147,000 kilometers [91,000 miles]. This allows the orbiter to make a series of passes by Triton, perhaps to determine what catastrophe shoved the satellite into a rapidly decaying retrograde orbit that dooms it to destruction in less than 100 million years. (Some think the same catastrophe may have knocked Pluto out of Neptune's orbit to become a planet in its own right.)

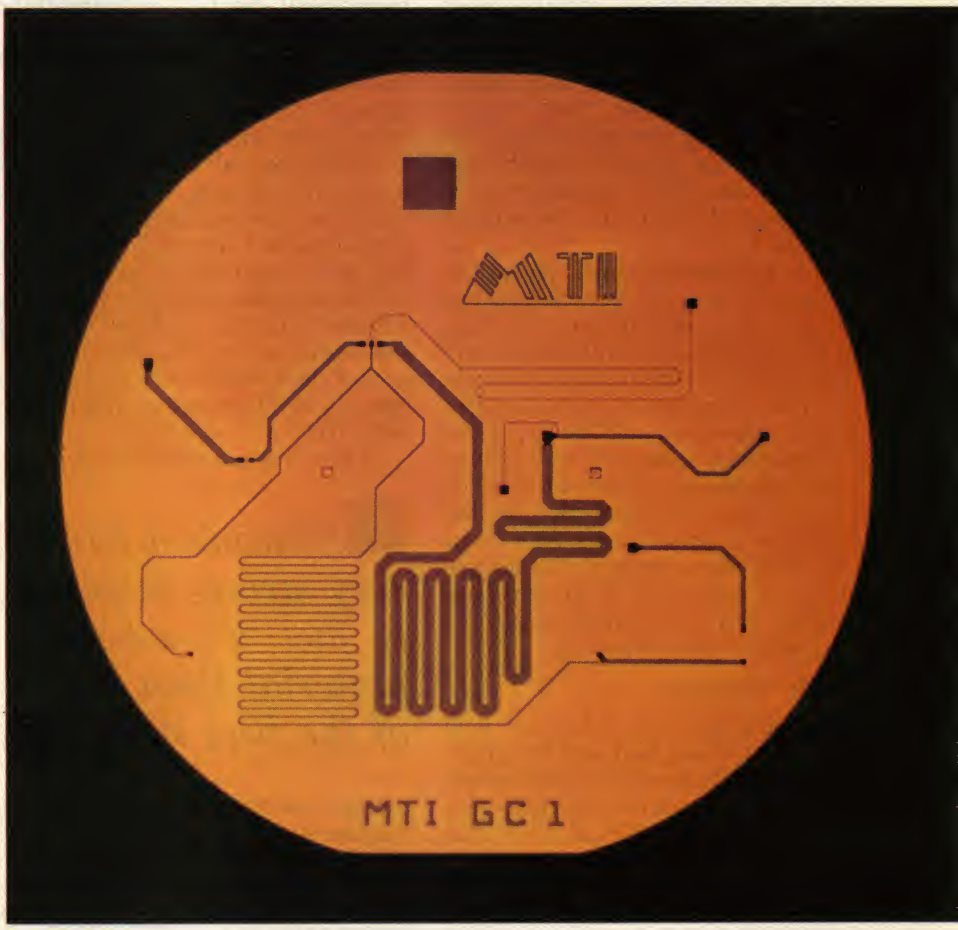
The proposed Neptune spacecraft looks good on paper: A uranium-fueled reactor would produce heat, which would be carried by heat pipes to silicon-germanium converters. These would produce electricity to power the ion engines and the scientific experiments. But can it be done?

The researchers at JPL and the reactor-design team at Los Alamos think it can, and space-reactor designs are being actively studied. Last year the Department of Defense joined NASA and the DOE in sponsoring a joint space-reactor program, and private industry was invited to submit proposals. Early this January two such proposals were accepted for further development: one from General Electric, which embodies much of the technology developed to date, and another from General Atomic and Martin Marietta.

With continuing support, in 10 to 20 years it should be possible to build space reactors capable of providing hundreds—perhaps even thousands—of megawatts of power. These reactors could power ion engines that would send our spacecraft to Neptune and the other outer planets; they could generate electricity to sustain permanent bases on the moon and Mars. The implications of this technology were summed up in a paper presented by David Buden, then the manager of the project at Los Alamos, and Joseph A. Angelo Jr. at the XXXII International Astronautical Congress in 1981: "... the development of advanced space nuclear-power systems ... is a critical technology step in the humanization of space," they told the audience. "Without space nuclear power ... man rejects his ultimate role in the cosmic scheme of things. With the energy of the atomic nucleus humanity can continue on its journey to the stars!" PS

The coming age of micromachines

Tiny mechanisms—valves, accelerometers, pressure sensors—can be etched in batches on silicon wafers then sliced into separate chips. These devices, ideally sized for linkup with microelectronic circuits, can monitor pollution, aid medical research, give robots a sense of touch, and more.



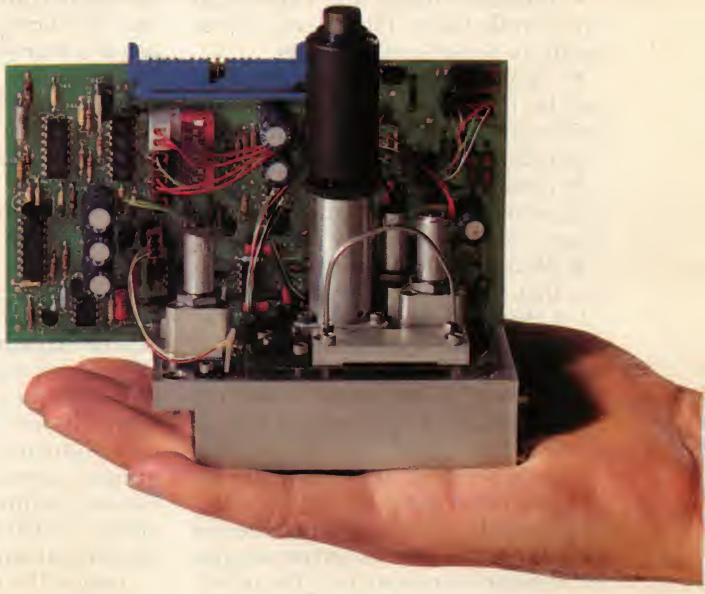
By JEANNE McDERMOTT
Drawings by Ed Lipinski

Fremont, Calif.

Jim Knutti, president and cofounder of Transensory Devices, Inc., held up a gray silicon device no bigger than a teardrop. It had two tiny terraces—pressure-sensing diaphragms—barely visible to the naked eye. I was looking at a miniscule "smart" pressure sensor, one of the incredible new breed of micromachines.

TDI's sensor, I discovered, is made much like millions of other microelectronic chips ["Superchips," PS,

Continued



Three-in. silicon wafer (above) is etched with key elements of a gas chromatographer, a device that identifies the components of a gas mixture. In a chromatograph, gases are forced through a column of material that absorbs and then releases each component. The time it takes a particular gas to pass through the column and reach a sensor identifies it. On the wafer, made by MTI, the etched snake-like channels are sealed with a glass cover. Gases are admitted into or exhausted from these channels by solenoid-actuated valves and small squares etched through the wafer. Initially the gas sample is compressed into the thick wafer channel; then it's released into both the narrower delay channel and a gas-separation channel outside the wafer. The separation channel, packed with porous polymer particles, is the U-shape metal tube on the right side of MTI's chromatographic module (right). Then, at different times, the separated gases and still-mixed (reference) gases from the delay channel are passed over a sensor that generates voltage peaks. An oscilloscope, pen plotter, or liquid-crystal panel can display a chromatographer's output as "spikes" for various gases or as numbers. Such miniaturization could lead to walkie-talkie-size instruments, says MTI. Its latest chromatographer is housed, with a microcomputer and five wafer modules, in a 14-by-seven-by-20-in. case.

April '83] in nearby Silicon Valley: Workers in gloves, smocks, caps, and booties that hood their jogging shoes process shiny, silicon-wafer discs, which are used to make microchips. They work behind glass windows in super-clean rooms, wary of dust motes big enough to muck up the works.

But TDI's production lines differ from those of most of its neighbors. Although the wafers that flow along them are layered with hundreds of familiar microscopic circuits—later sliced into individual chips—TDI also sculpts mechanical devices into the silicon at the same time that microcircuits are produced. These exquisitely precise microscopic shapes work not in two but in three dimensions. "We call the other manufacturers flatlanders," Knutti said. "We work in the hills."

This mechanical dimension to the Silicon Age evolved over the last two decades, along with miniaturized transistors, integrated circuits, and the microprocessor, or computer-on-a-chip. As electronic components became smaller, more streamlined, and less expensive to manufacture, the gulf widened between microelectronics and the bulky, costly mechanical sensors that feed information to microcircuits. As a result there has been a growing call for mechanical devices that are precise, reliable, and tiny enough to join the microelectronics revolution.

To the rescue

Micromechanics is a hot new field that is answering that call. By adapting technologies used for integrated-circuit manufacturing, engineers are building remarkable devices that range from simple stationary parts, using special properties of silicon, to complicated active sensors:

- Intricate tubing and valves that can shrink bulky laboratory instruments to pocket-sized devices.
- Tiny temperature sensors that can be injected into tumors and be used with hyperthermia (body-heating) techniques to treat cancer.
- Pumps and valves that could be implanted to deliver regular doses of drugs such as insulin to patients.
- Nozzles, used in computer printers, that spray ink drops so small that 10 of them would fit in the period at the end of this sentence.
- Pressure sensors that can fit inside a blood vessel or be wired into artificial "skin" to give robots a sense of touch.

Micromechanics has been under development for the past 20 years. But only recently have engineers perfected the manufacturing expertise needed for commercial production. The micromachining techniques that create three-dimensional shapes have been refined to the point where they can be reliably repeated.

These techniques rely on photolithography, which transfers dozens or hundreds of identical patterns from a master photomask to sensitized silicon wafers. Strong acids and caustic liquids then etch away portions of the wafer. Finally, often after this sequence is repeated, individual micromechanical devices—micromachine chips—can be sliced from the wafer.

"With silicon micromechanics you can make very-high-precision structures on a mass-produced scale," explains Kurt Petersen, vice-president for technology at TDI. This is most important now that cheap computing power has spurred the demand for low-cost miniature sensors. "We will see the most tremendous use of micromechanical devices in transducers —sensors that let you know what the real world is," says Steve Terry, manager of electronics research and development at Microsensor Technology, Inc. (MTI).

At first it seems odd to think of silicon as a mechanical material. That's because silicon is brittle. But it turns out that silicon is quite robust. Jim Angell, associate chairman of the Department of Electrical Engineering at Stanford University, is quick to correct the common misperception: "Silicon is a marvelous material. It is very strong. In fact, it is a better material than some of the best steels you can find. To be sure, it is brittle: If you go beyond its elastic limit, it breaks. Steel just stretches." But silicon does not fatigue like steel. You can move it indefinitely within its range, and it won't give out.

"Silicon's a terrific, very strong material. In fact, it's a better material than some of the best steels"

Two properties of silicon determine what types of sensors can be made. Silicon is piezoresistive—if you strain it, its resistance changes. Also, it physically moves in response to pressure. "If you can measure strain or displacement, you can make strain gauges, pressure sensors, friction sensors, torque sensors, and accelerometers. That's about as far as micromechanical sensors can go," says Terry.

Among the early champions of the field of silicon micromechanics are Angell and Ken Wise, now the head of the Electron Physics Laboratory at the University of Michigan. And if any place can be called home to micromechanics, it is the Integrated Circuit Laboratory at Stanford.

In the early 1970s researchers at NASA's Ames Research Center in nearby Sunnyvale, Calif., visited Stanford. They asked the Stanford group to design a tiny gas chromatographer (see photo), a device for separating, identifying, and analyzing gas-mixture components, that would be small enough to fly on the Viking lander to Mars. The plan was to use it to test for signs of life on the red planet. Angell gave the assignment to Terry, then a graduate student and later a founder of MTI.

In a chromatographer, an inert carrier gas such as helium sweeps the gas mixture to be analyzed through a column of material that separates the gaseous components. Terry started by shrinking the column. He etched a U-shape groove into an entire silicon wafer three inches across, winding it in a spiral so the column would be long enough to separate out the gases (with a liquid coating on its inner surface). He covered the trench with a glass backing, which effectively created a long, sealed tube.

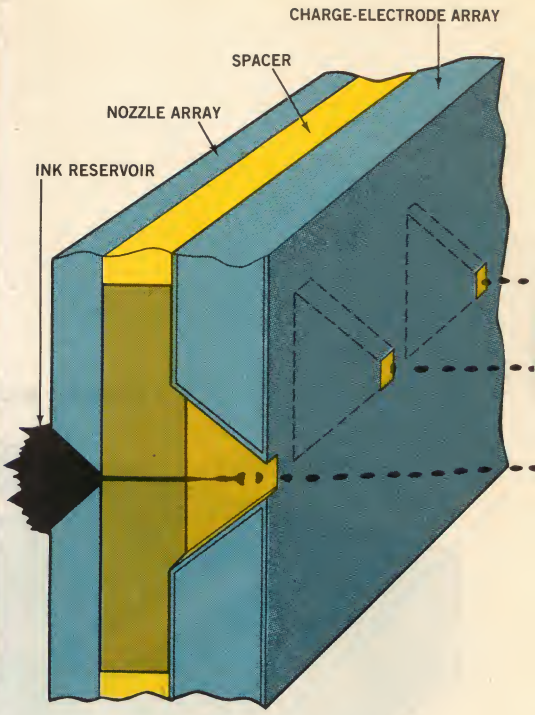
Unfortunately he did not know how to make a valve small enough to deliver the sample gas or a detector sensitive enough to register the change in thermal conductivity of the gas emerging from the column. He did not see the device go to Mars.

With a grant from the National Institute for Occupational Safety and Health (NIOSH), however, Terry persevered. NIOSH wanted a pocket-sized device that inspectors could carry to identify hazardous gases. Four years after he started Terry succeeded in integrating the column, valve, and detector into one wafer. The wafer fits inside an instrument that is eight inches by eight inches. Terry etched a valve, complete with a sealing ring, that stays open for five milliseconds and accepts 10 nanoliters (billionths of a liter) of gas. He also etched a well small enough to collect a sample gas, which is then detected by a thermal-conductivity sensor.

Injected sensor

Meanwhile, Angell and Phil Barth, a research associate at Stanford, are turning their attention to biomedicine. They are developing a temperature sensor that could be used in killing cancers with heat. Hyperthermia involves raising the temperature of parts of the body to 43 degrees C (109.4 F)





Droplets of ink, looking like dewdrops on a spider's web, fly from an array of nozzles etched into silicon by IBM. Ink-jet printers using such nozzles provide a silent method of forming alphanumerics and graphics. An electric charge can be induced on individual droplets as they leave each nozzle. Drops are then guided to the paper by an electrostatic field. Etching enables ink holes to be formed with precision. A variety of designs, such as this early IBM array, have been developed.



Mask combining microelectronic-micromachine functions is examined by TDI's Jim Knutti and Doug Jachowski.

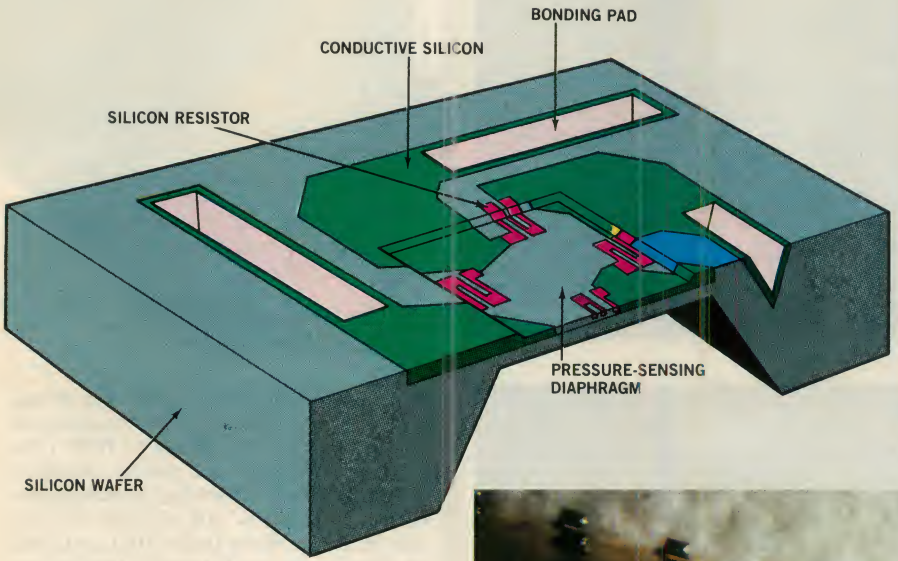
with ultrasound or radio-frequency energy.

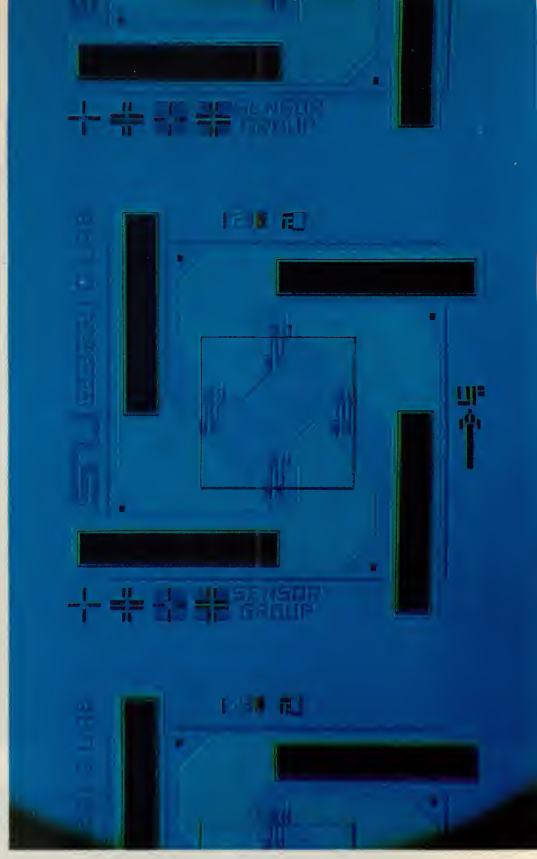
But it's difficult for a physician to know if the temperature around the tumor has reached that level. Not enough heat is ineffective; too much harms surrounding tissue. The sensor is designed to be injected in the tumor area with a syringe and remain only while heat is applied.

Barth pulled a syringe from his desk drawer and showed me how the temperature sensor is small enough to fit inside the needle. It's a pretty device, a series of beads no bigger than grains of salt stuck to a flexible yellow-plastic backing.

Biomedical applications have been proposed for other micromachines. Barth suggests using a pressure sensor during an operation called angioplasty, which involves clearing away plaque that hardens on the walls of the arteries by pushing a tiny balloon through the arteries. A pressure sen-

Continued







Pressure sensor is formed by etching part of silicon wafer until a thin diaphragm is created (square at center). Thin silicon resistors bridging the diaphragm and wafer change value when pressure changes flex the membrane. Wires are attached to the gold-plated grooves. Sensor chip, just 0.02 in. on each side, can be fabricated in large numbers with photolithographic techniques that duplicate sensor pattern hundreds of times on a wafer.

Silicon pressure sensors the size of salt grains are embedded in a plastic sheet. Linked together by conductors in polyimide material, the sensor matrix could serve as the "skin" for robots. It's under development at Stanford.



Accelerometer developed for biomedical monitoring, such as sensing heart-muscle movements, is formed by separating section of wafer except for narrow bar. Resistor formed on support bar changes value when motion vibrates cantilever beam (main silicon mass), developing a signal. Also developed at Stanford, device is 0.1 by 0.3 in. and is etched on a wafer.

sor placed right behind the balloon would tell the physician how well the plaque had been cleared. Pumps and valves, which may be made of silicon, could also be implanted in the body and be used to deliver regular doses of drugs such as insulin.

Angell's group at Stanford is not the only center for silicon micromechanics. Over the past decade IBM has supported its own group. Unfortunately it tends to be more tight-lipped about the group's activities.

One early IBM project was a nozzle for ink-jet printers. These are letter-quality printers that deliver ink to the page as a stream of very fine droplets ["Quiet—High-Tech Printers at Work," PS, Feb.]. Drop placement on the page may be controlled electrostatically. Rather than make the nozzles out of quartz and drill the orifices with an electron beam (a time-consuming process), IBM wondered if micromachining silicon would result in a cheaper nozzle.

Ernest Bassous, a chemist at IBM in Harrison, N.Y.; Larry Kuhn, also of IBM; and others led the effort in the early 1970s. Using caustic etching fluids, they made pyramid-shape entry holes in a wafer 10 millimeters (0.4 in.) thick and let the etchant work its way through until it made a small exit hole. The problem was how to make uniform orifices, only 20 microns (0.008 in.) in diameter, each time. If each orifice is not identical, the characters have fuzzy edges. The sight may not be visible to the untutored eye, but it jumps out at an expert. "It took us three years to demonstrate repeatability. You don't find instructions on how to do these things," says Bassous. Although the problem of making ink-jet nozzles was solved (as will be described shortly), other problems plagued the device and kept it from being marketed.

Twenty-year evolution

Developing the micromachining techniques for all of these devices —including the solution to IBM's ink-jet-nozzle uniformity problem—has involved many refinements in etching technology. The evolution really began in 1965 when a neurologist from the Stanford Medical School asked Angell if he could make an array of brain electrodes using integrated-circuit technology. Angell turned the problem over to Ken Wise, then a graduate student. Instead of making a needle-like probe by drawing out a glass capillary pipette, the idea was to make the probe out of silicon.

Wise turned to chemical etches. At the time, integrated-circuit manufacturers sometimes used a chemical etchant, instead of a sawing or scribing method, to break apart a delicate wafer. Nobody used them to shape silicon. "When we started, the only etchants available were isotropic etchants," Wise says. Isotropic etchants, such as nitric or hydrofluoric acid, devour silicon willy-nilly in all directions, without regard to the shape or orientation of the crystal.

"The etchants were good," says Wise. "But only on a good day." Isotropic etchants have several drawbacks: They undercut the photomask patterns so that any shape they create is smaller near the surface and wider at the bottom of the pit. They are also sensitive to agitation. The brisk boot heel of a passerby stirs up turbulence, changing the rate at which the acid attacks silicon.

Still, Wise demonstrated that the brain probe could be made. This success caught the attention of researchers at NASA's Ames center. They asked the Stanford group to design a pressure sensor on a silicon chip. Pressure sensors work in many ways, but all have a diaphragm that moves in response to changes in pressure. The idea was to etch a diaphragm into the silicon chip by removing an appropriate amount of material from both the top and bottom.

> *"The fingertip has the equivalent of 10,000 sensors. Robots could approach that sensitivity"*

To make the diaphragm meant using a more precise but even more finicky class of etchants known as anisotropic etchants. Anisotropic etchants such as potassium hydroxide are the finer tools of the micromachinist. These fluids excavate the silicon wafer depending on the orientation of planes—relationships between atoms within cube-shape silicon crystals. Certain planes are etched away faster than others. "The shapes are provided by nature," explains IBM's Bassous. "The etchant takes advantage of what nature wants to do."

Anisotropic etchants carve out pits that do not widen as they are deepened. The pits typically have well-defined walls. V-shape trenches can be made, as well as pyramidal or faceted holes. But the shape of the silicon crystal dictates certain geometries and disqualifies others. Two walls can never be perpendicular: They will always slope out. A right angle or perfect corner can't be made.

At the time that Wise worked on the pressure sensor, anisotropic etchants were hard to control. As Angell describes it, "The early work involved developing recipes the way a cook does. Some work. Some don't. You keep careful records so you know everything that you did. If something works, you can repeat it."

Fortunately Wise heard in the early 1970s that anisotropic etchants are sensitive to boron atoms inserted into silicon's crystalline structure. "You can put boron in silicon, and the etchant suddenly stops," explains Wise. The boron trick solved the problem of how to make a thin silicon diaphragm, with precise and even dimensions each time. This technique also enabled IBM researchers to etch through a surface and produce nozzles of precisely equal size.

Now, more than 10 years later, a handful of companies are marketing silicon pressure sensors. TDI, which started less than two years ago, offers a single-chip sensor that detects two different pressures as well as temperature. The tiny device, which is more precise than anything that could be machined, sells for between $20 and $200—and that's relatively expensive.

Computer talk

Why the expense? The pressure sensors are smart. That means they contain electronic circuitry that processes the signal from the sensors and amplifies, streamlines, and even formats it for a computer.

Just as smart pressure and temperature sensors are needed that can "talk" with computers, the same need for integrated sensors applies to robotics ["Robots that Think," PS, June '80]. Along with their biomedical research, Barth and Angell are exploring the use of pressure sensors for robotic fingertips. If robots are ever to develop the flexibility that is their perceived hallmark, they need to interact with the environment. Humans rely on a vast number of sensors to do that. In the fingertip alone we have the equivalent of 10,000 sensors. By placing silicon pressure sensors on a flexible backing (see photo, opposite page), robots could approach that level of tactile sensitivity.

By themselves, silicon nozzles, pressure sensors, and gas chromatographers are hardly exotic. But by virtue of their diminutive size, these micromachines are being put to a variety of exotic uses. "All we've done is shrink these things," says MTI's Terry. There is no way to measure how big that step is. PS

What's New

products/technology



Solar charger

Keep 12-volt boat or RV batteries trickle charging with its portable solar-cell module, says ARCO Solar (21011 Warner Center Lane, Box 4400, Woodland Hills, Calif. 91365). The $195 M82 module delivers seven watts of peak power. Encapsulated within the panel are 35 solar cells.



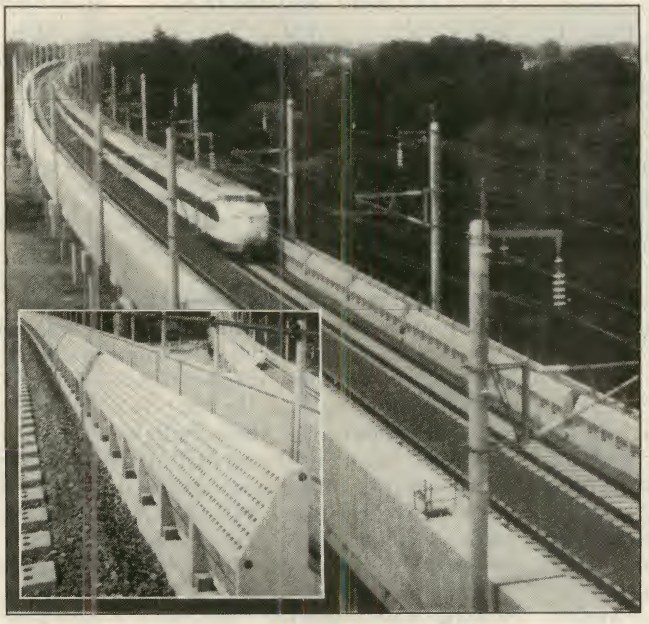


Super sponge

A rolling sponge—thick plastic foam over a 30-in.-dia. drum—quickly clears a rain-soaked park, golf course, or tennis court. Water is squeegeed into a 12-gal. tank. A five-hp engine drives the 95-lb. drum. Motomop Ltd., 2 The Crescent, Taunon, Somerset TA1 4EA, England.

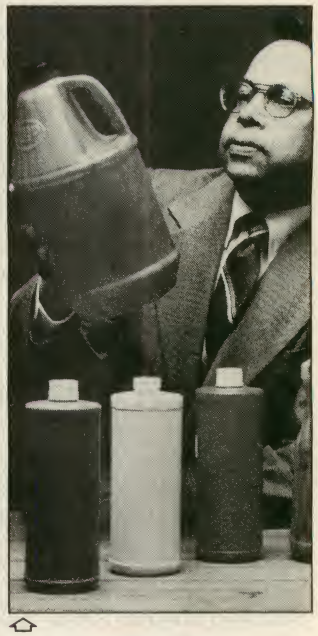
Quiet jet

Boeing's 737-300 twin-jet airliner has forward-mounted French-U.S. turbofan engines for quieter takeoffs and less fuel consumption. The aircraft, a larger version of the 737-200 already used worldwide, carries 140 passengers in single-class service. It will fly this fall.



Noise barrier

Calm Zone is a waist-high noise-reduction barrier (inset) that can reduce highway and rail noise by 75 percent, claims Bridgestone Tire Co. (Los Angeles, Calif.). The baffle system uses sound refraction and interference. A rear fiberglass barrier increases baffle effectiveness.



Plastic barrier

A blend of polyethylene and nylon can replace costlier metal and glass containers to hold gasoline, says Du Pont Co. (Wilmington, Del.). A nylon called Selar forms overlapping barriers in containers during one-step molding. Barrier layers must be added to most plastics.

Japanese VW

The Volkswagen Santana four-door sedan entered full-scale production at a Nissan plant in Japan early this year. VW supplies engines, transmissions, and steering gears for the project. The front-drive Santana has longitudinally mounted diesel or gasoline engines.





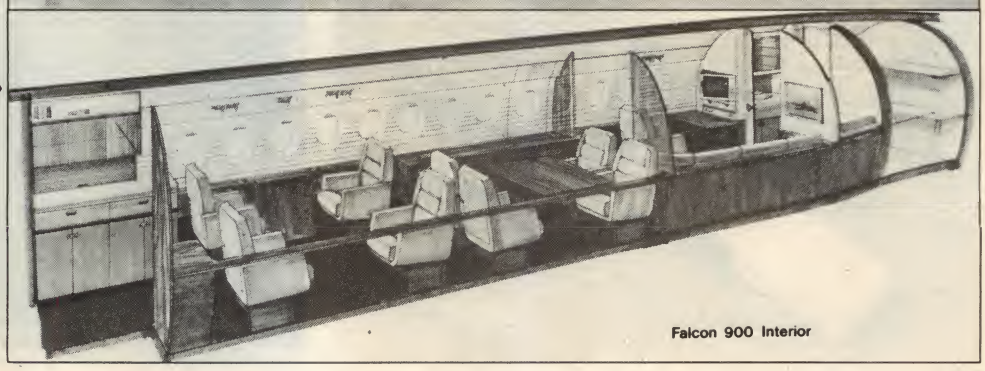
Safety seat

Style, flexibility, and comfort were missing from children's car seats until the Dutch Bobob 2, says Z.B. Sales (601 Eastover Pkwy., Locust Grove, Va. 22508). A lever reclines the $150 seat, and the removable upholstery is washable. It has a one-button fast-release harness.

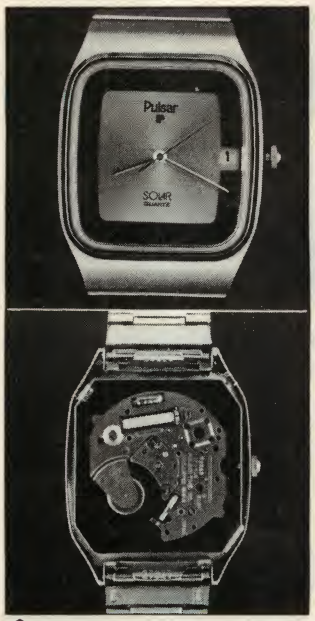


Long-range tri-jet

Executives can stretch out aboard the roomy Falcon 900 business tri-jet. Wide-mouth Garrett fanjet engines provide a 500-mph cruising speed and 4,800-mile range with reserve fuel—enough for Atlantic crossings or nonstops from Anchorage to Tokyo. It seats 12 to 15.

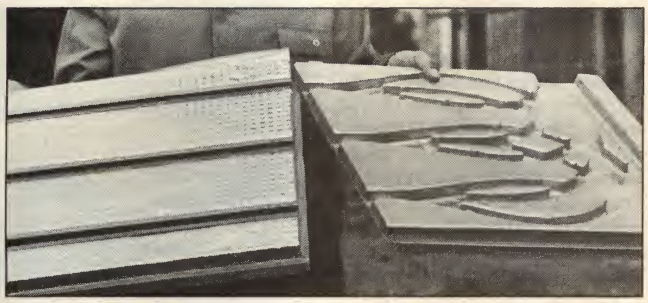


Falcon 900 Interior



Battery-free watch

You don't have to replace rechargeable batteries in its light-powered quartz watch, says Pulsar. Special solar cells sensitive to indoor light charge a condenser that drives a step motor. Coming this fall, three-hand calendar and day-date men's models will cost $100 to $200.



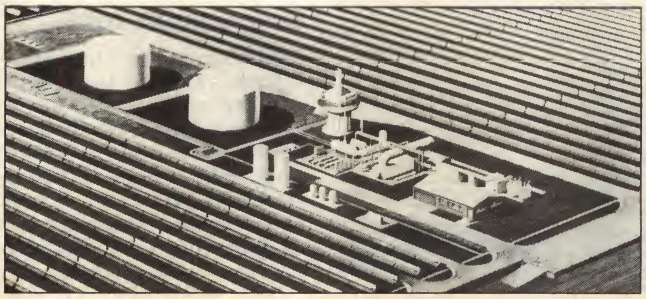
Floor panels

Prefabricated plastic-foam slabs for under-floor heating are designed to hold flexible water pipes. The panels provide good thermal insulation and soften footsteps as well. Locking overlaps anchor them. Gebr. Risse GmbH, Erleustrasse 50, 5757 Wickede/Ruhr, W. Germany.



Italian dual-turbo

Twin turbos and a three-valve head (two intake, one exhaust) enhance performance on its $26,000 Biturbo, says Maserati. The dual-turbo system ensures immediate, smooth accelerator response, claims the maker. Front seats slide forward for rear-seat access.



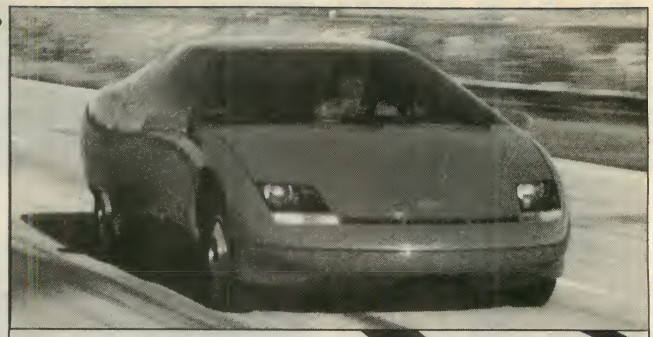
45-MW solar plant

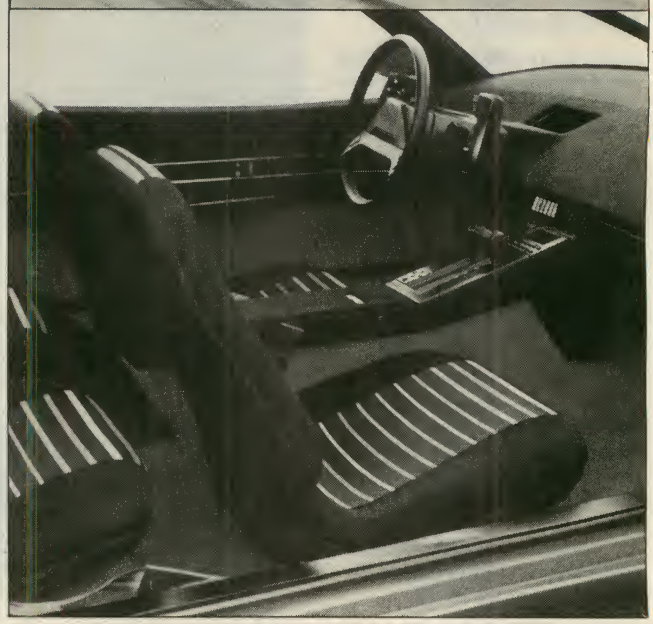
SEGS I, a sun-powered electric plant, will be the world's largest (45 megawatts) next year, says Luz Engineering Corp. (Encino, Calif.). The utility station, in Southern California's Mojave Desert, uses parabolic reflectors to heat oil, produce steam, and drive turbines.

What's New

Slippery concept

GM's concept car, the Citation IV, has the lowest coefficient of drag (0.185) of any GM road car. Super-slippery styling includes handle-free, computer-opened doors. Inside (below right), a digital instrument display is sunk into a deep, padded dash.





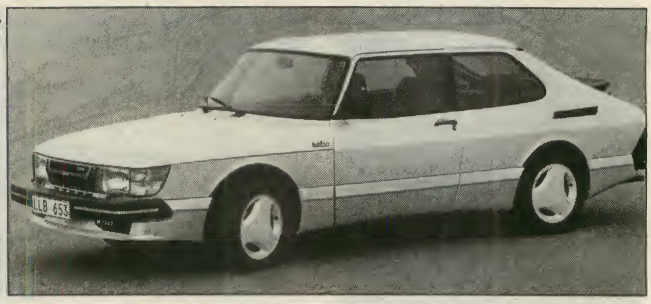


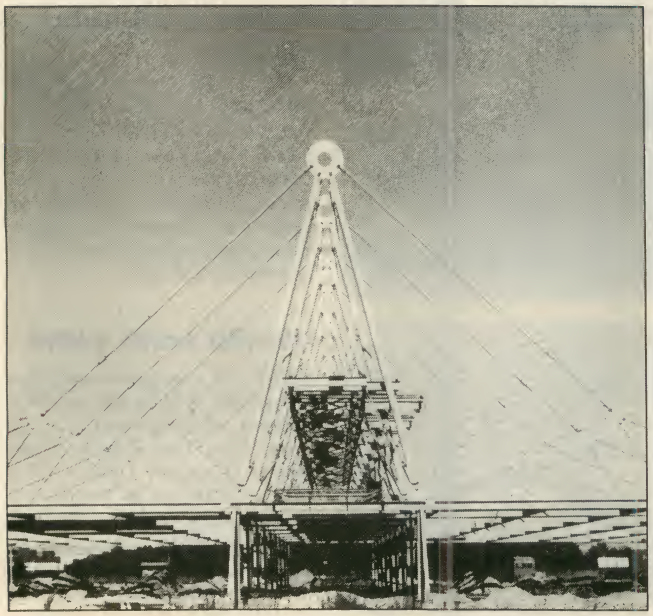
Rescue phone

Worried about an elderly relative living alone? The AT&T Emergency Call System has a portable transmitter. Press it, and the phone alternately dials two pre-programmed numbers until the call is answered. A synthesized voice requests help. Price: $250.

Super-coupe

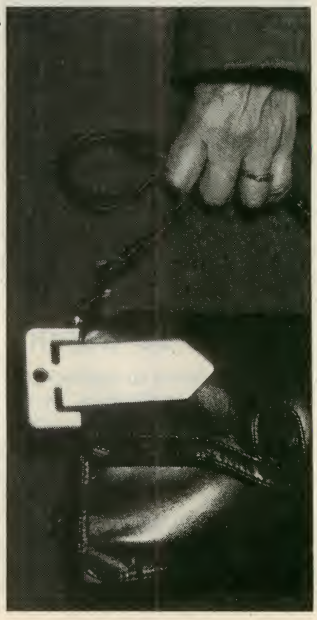
An easier-breathing 16-valve engine gives the Saab Turbo 16 Aero a top speed of 130 mph. The two-liter (122-cu.-in.) four-cylinder power plant also produces acceleration from zero to 62 mph in 8.7 seconds. But like its slower siblings, the 16 gets 33 mpg on the highway, says Saab.





Safety clip

Shining brightly in a headlight's glare, the reflective clip on the purse alerts a driver 100 ft. away. The safety device, a plastic paper clip covered with 3M reflecting foil, was developed by a German safety council for elderly pedestrians.



Suspension roof

Cables strung from nine steel A-frames support the roof of a 42,000-sq.-ft. building in East Windsor, N.J. To free floor space, roof-mounted pods will house utilities. Ductwork will carry wiring and plumbing in through the modular roof. PA Consulting Services owns the building.

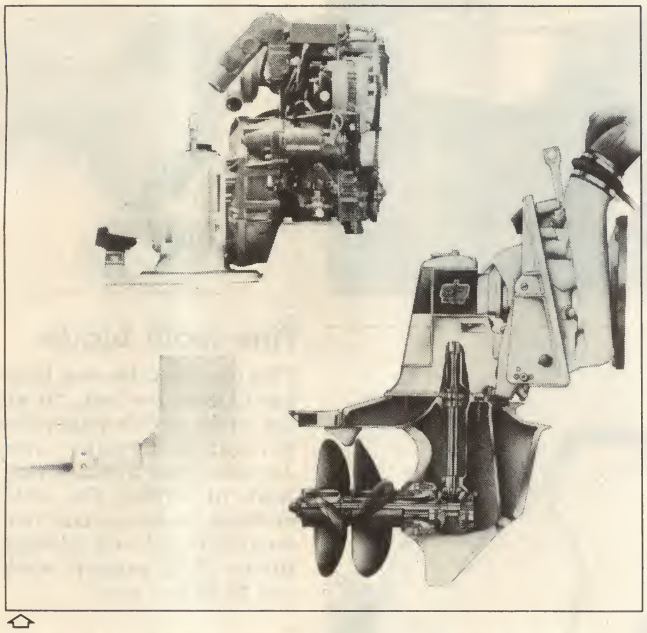
What's New *in Boating*

BY SUSAN RENNER-SMITH

Sporty sailer

Mate a sail board with a dinghy, and you get the Tonic. Its unstayed, wishbone-boom mast supports a 75-sq.-ft. sail. With lowered centerboard, the 12-ft. fiberglass hull has a draft of 2.7 ft. Maker: Sailskiff, Box 15, Southmour Lane, Havant, Hants PO9 1JJ, England.





Swedish diesel and fuel-efficient drive

It weighs 246 lbs. and displaces just 26 cu. in., but the Volvo Penta 2001R (left) produces nine hp for becalmed sailers. Adjustable rubber mounts minimize vibration. Closed-crankcase ventilation, a seawater-cooled exhaust system, and a fully enclosed flywheel make for quiet running. The Duoprop Drive's twin props (right) boost acceleration by 30 percent while reducing fuel consumption by 15 percent, says Volvo Penta. The counterrotating props also reduce steering torque, improving maneuverability. The drive is available on the D30- and D40-series turbocharged diesels.





Three-point hull

For in-water stability and protection for the prop when beached, the Gullwing 24 has two skegs aft and a single keel forward. The shallow-draft craft (1.5 ft.) can be built in wood, fiberglass, or aluminum. It's made by Gullwing, 5307 N. Pearl St., Tacoma, Wash. 98407.



Add-on compass

Binoculars do double duty with the Binocom. Attached to the objective lens, it gives the compass heading of an object viewed through the lens (inset). The device fits most binoculars. Price: $25.50 plus postage from Goldbergs' Marine, 202 Market St., Philadelphia, Pa. 19106.

Pedal pusher

To free both hands for sail-tending, the Sunbird steers with foot pedals linked to the rudder via steel cables. The 15.5-ft. boat's weighted, retractable keel helps the boat go half as fast as the wind, says Bellway Marine (Consett, County Durham DH8 6SX, England).

What's New *in Tools*

BY V. ELAINE SMAY



Buzzing butler

A mini vacuum cleaner powered by four AA cells clears crumbs from the table—or sawdust from the workbench. Stubby bristles at the base loosen dirt on fabric. A screen opens to empty the vacuum. Frontier Mail Ltd., 78 Chamberlayne Rd., London NW10 3JU, England.



Recharging riveter

With a one-hour charge of its nicad batteries, the ADR-48 riveter will place more than 300 blind rivets, according to Avdel (50 Lackawanna Ave., Parsippany, N.J. 07054). The three-lb., $249 tool comes with battery pack, 115-VAC charger, and nosepieces for 1/8-to-3/16-in. rivets.

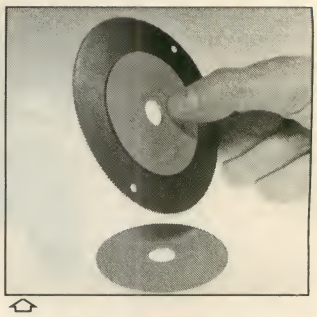
One-pass mower

Accessories available for the Simplicity 4211 tractor let you de-thatch your lawn, mow it, and collect the clippings in one operation. The tractor has electronic ignition and a five-speed transmission. Suggested price (with hydrostatic transmission and mower): $2,450.



Mid-size tractor

"It fits the niche between lawn tractors and lawn-and-garden machines," says Ford of its new YT-16. "It tills, mows, hauls, and removes snow—at an affordable ($2,586) price." Features? A 16-hp engine, electronic ignition, and five-speed-plus-reverse transmission.



Fine-tooth blade

This four-in. table-saw blade has 15 teeth per inch. "It will rip some woods paper-thin yet cut 5/8-in. oak," says Jarmac (Box 2785, Springfield, Ill. 62708). The 0.016-in.-thick blade also cuts nonferrous metal and plastics. Blade: $7.45; support washers: $2.50 per pair.



Mini-tools

Woodworkers, model-makers, potters, and microcircuit builders are finding dental tools just what the doctor ordered. Huckleberry Finn (Box 109, Port Orford, Ore. 97465) offers factory rejects and overstocks at low prices: An economy set of five is $7, for example.



What's New *in Home Improvement*

BY SUSAN RENNER-SMITH

Fast freezer

A stream of supercold air freezes food twice as fast as the shelf-mounted freezing coils in conventional freezers, says Admiral. The Ultra-freeze process forms smaller ice crystals that alter the food's structure less, so it tastes fresher when thawed. Its price is $599.





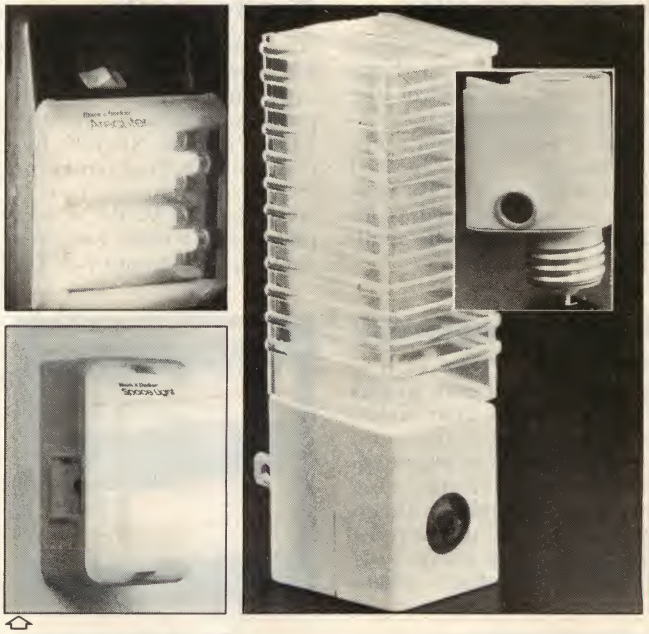
Simple skylight

You can install a skylight without climbing the roof, says APC Corp. (Box 515, Hawthorne, N.J. 07507). The two parts of the Roof-Lights skylight are lifted through a hole cut from inside. With the "curb" unit in place, the glazing assembly is screwed to attic rafters.



Super-stain

The Weatherbeater exterior oil stain will repel water for at least two years; Sears guarantees it. It's also guaranteed not to crack, peel, or blister for three years. The mildew-resistant stain comes in several finishes and colors, and it costs $18 per gal.

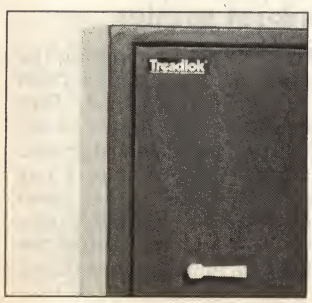


Four handy lights

Black & Decker's $35 battery-powered AreaLiter (top left) provides six hours of soft fluorescent light for campsite or patio. B&D's Space Light (above left) illuminates dark closets, holds a charge for months. The $20 light has a slide-off wall mount for easy recharging. Both will be available this fall. Photocells switch on the $5 Good Nite Light (above center) and the $8 screw-in Night Eye lamp timer (inset). New? No. But unlike similar products these have solid-state circuitry that produces flicker-free light, claims Diablo (2694 Bishop Dr., San Ramon, Calif. 94583).

Invisible lock

It looks like a conventional steel safe—but there's no combination lock to spin. A programmable electronic lock hides in the Treadlok nameplate, which has membrane switches behind each letter. Tread Corp. (Box 13207, Roanoke, Va. 24032) sells model 605 (shown) for $910.

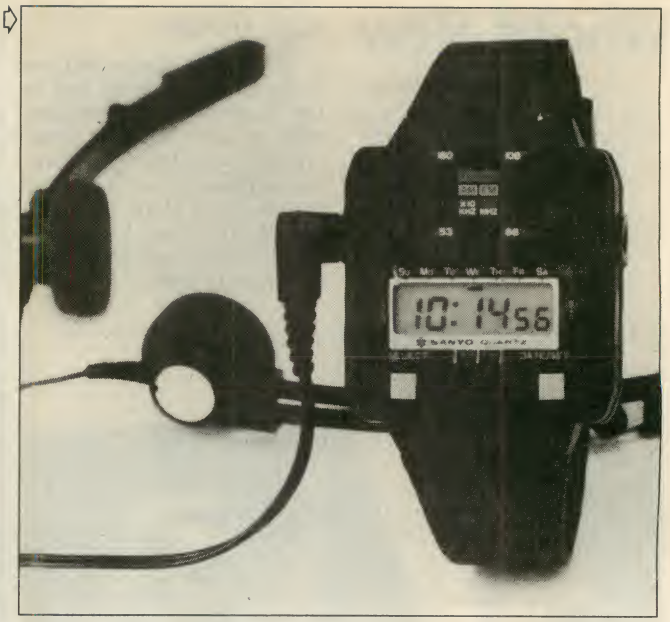


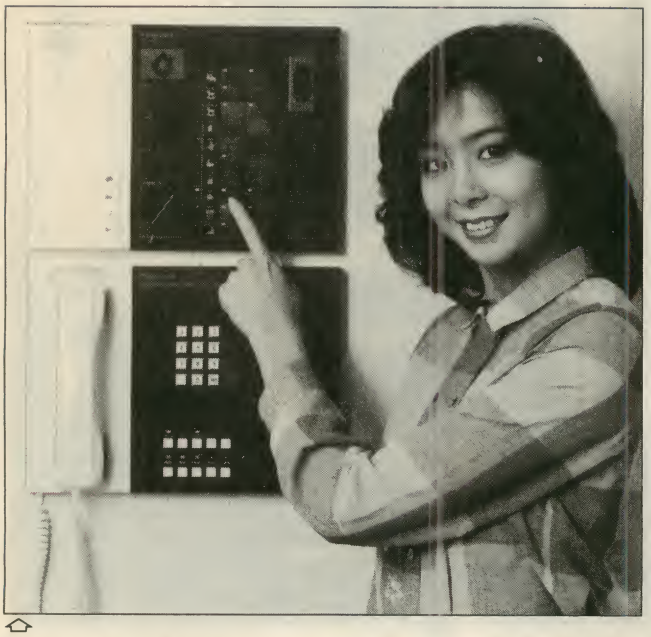
What's New *in Electronics*

BY WILLIAM J. HAWKINS

AM-FM wristwatch

Any watch will give you the time, but this Sanyo model also gives the weather, local news, and even music. How? It's a complete AM-FM radio. It plays for seven hours on FM, up to 60 hours on AM using two silver oxide batteries. U.S. price is not yet set, but in Japan it's $49.







Data scrambler

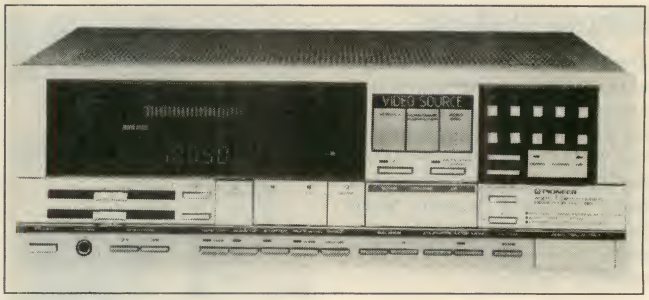
Connect Commlock between your computer and a modem, and the data is scrambled for security before it's sent. A second Commlock unscrambles the data at the receiving end. Maker: ADM Concepts, 1445 Los Angeles Ave., Simi Valley, Calif. 93065. Price: $600.

Home controller

If the Toshiba Home Controller answers when you phone home, you can control any appliance remotely. If something is wrong—from a fire to a burglary—a synthesized voice will tell you. The system can also be used as an intercom. It should be available later this year.

Control center

It's a complete 125-watt AM-FM receiver with inputs for tape and a turntable. But push more buttons, and the $800 Pioneer SX-V90 becomes a switching center for video components, too. It controls two VCRs, a disc player, and a video game for viewing on a monitor or TV.

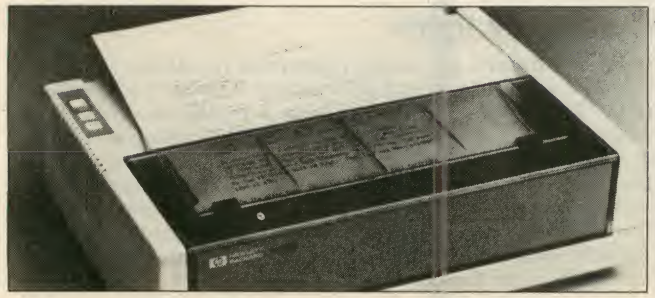


Home/portable VCR

The Sharp VC-363 VCR is battery-powered and weighs just 13 pounds. That makes it portable, right? Yes, but it also has a built-in 105-channel tuner; seven-day, one-event programmable timer; and a pop-in AC power pack. That makes it perfect for home use, too. Price: $900.







Ink-jet printer

The only thing touching the paper is ink sprayed from an ink-jet print head. That means the $495 battery-powered Hewlett-Packard printer is fast (150 characters per second), quiet (noise level less than 50 dB), and versatile (11-by-12-dot matrix for multiple fonts and graphics).

Video processor

Connect a video source to the V615A processor for enhanced color, tint, and signal levels. Result: high-quality video pictures and tape dubs through its RF or four video outputs. It also handles stereo audio. Maker: Recoton, 46-23 Crane St., Long Island City, N.Y. 11101. It's $330.

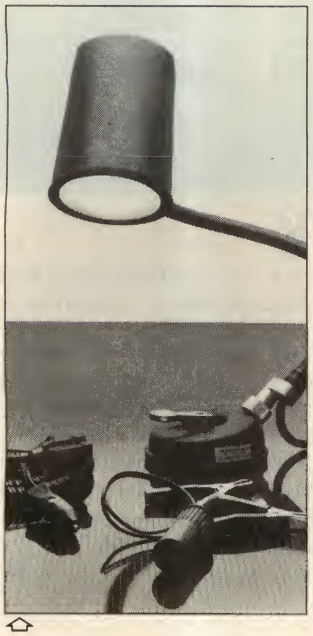
What's New *for Your Car*

BY JACK KEEBLER

Crisscross tire

The Vector is Goodyear's third-generation all-season tire. The computer-designed tread and better rubber compounds are claimed to improve tread life, wet traction, and fuel economy. They also quiet tire noise. Available in 25 sizes, prices range from $61.95 to $99.50.





Suction-cup light

An aluminum heat sink keeps the Lexan shade cool to the touch, and the suction-cup base clings to any smooth surface, claims CKR Inc. (Box 6943, St. Louis, Mo. 63123). A vinyl-covered gooseneck swivels to position the light where it's needed. Price: $49.95.



Hidden storage

Compact Tool-Bin, composed of four carpeted shelves, fits behind a pickup's seat to store tools, guns, or fishing equipment. Made of 26-gauge rustproof steel by Crafco Mfg., Inc. (3639 E. Superior, Phoenix, Ariz. 85040), the box comes in three sizes and costs $79.95 for any size.



12-V auto brush

Car Scrubber from Black & Decker plugs into the cigarette lighter yet is safe to use with water and cleaning agents. Interchangeable brushes and an 18-ft. cord make the electric brush suitable for interior and exterior cleaning jobs. Approximate retail price: $30.



Accident kit

Pictures help support your insurance claim. Included in the $29.95 Eyewitness Accident Photo Kit are: a preloaded 110 camera, flip flash, prepaid processing mailer, accident report forms, and a pen. PM Industries (5946 Kester Ave., Van Nuys, Calif. 91411) makes it.

Battery watcher

The model 330 Battery Monitor gives both a visual and audio warning when the battery's charge condition drops below normal, says Fleet Specialties Div. (Box 4575, Thousand Oaks, Calif. 91359). It even warns when the headlights have been left on. The monitor costs $24.95.





Boat loader

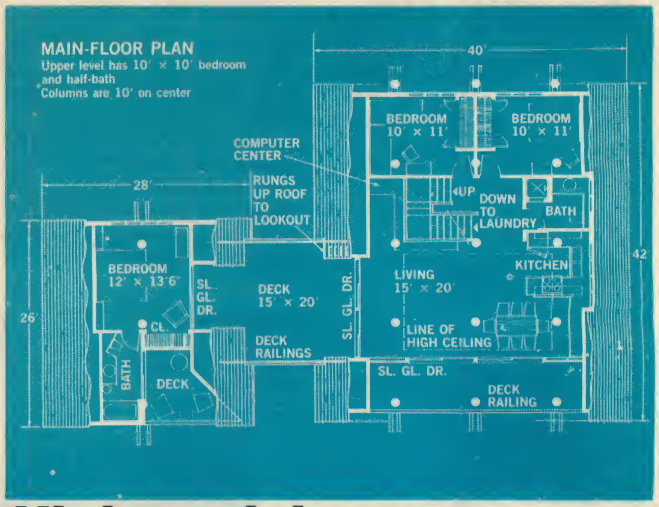
The EIDE Automatic Boat Loader uses a cable system to load car-top-size boats onto compact truck campers. Recreation Industries Co. (Box 68386, Oak Grove, Ore. 97286) claims the automatic rack accommodates boats wider than the top of the camper. Price: $495.

Popular Science
leisure homes of the month

Two designs linked to their sites

Who'd know better than environmental architect Malcolm Wells that housing must be sensitive to its site? That's why PS commissioned these two build-it-yourself paired units from this prize-winning designer.

By AL LEES



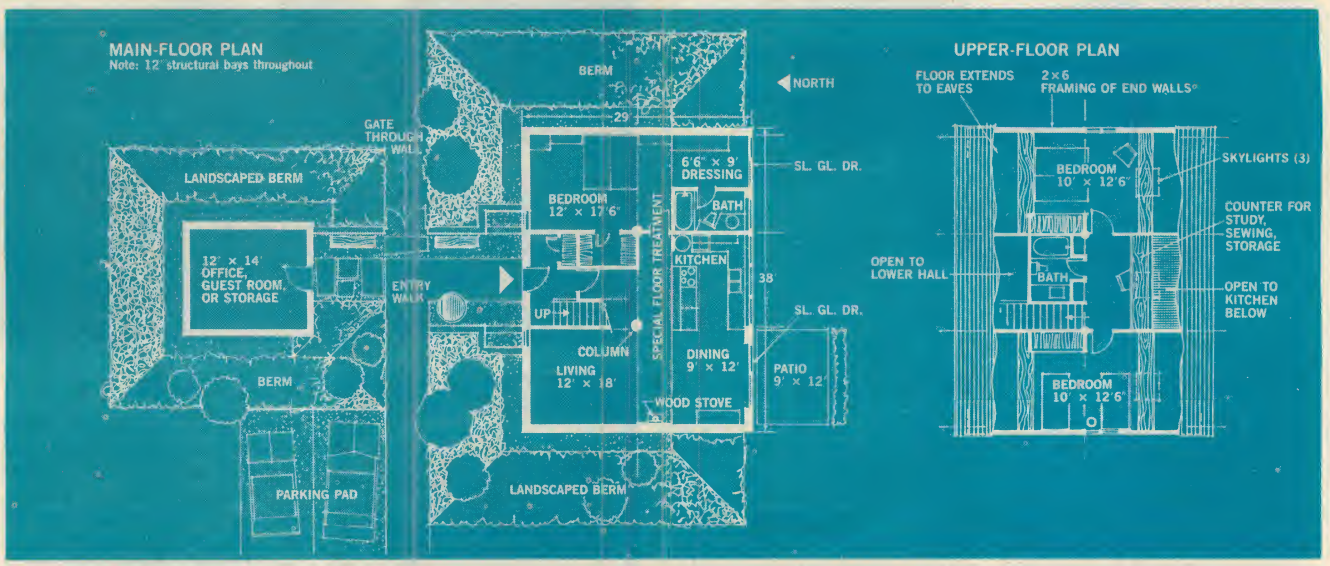
High and dry

There's virtually no disturbance of a waterside site with this pair of A-frames on stilts. Perched on treated wood pilings (or tube-formed concrete columns), the twin structures capture every breeze and every vista. As a start, build whichever unit the budget allows; add the second later. Primarily warm-season structures, they could be insulated for wood-stove heating. And for areas where storm tides or flash floods threaten, just build the utility-storage pedestal of breakaway materials so it won't form a dam against swift high water. The living units—sturdily constructed on 45-degree-angle framing—will ride high and dry above temporary flooding. PS

Low and bermed

Been looking for an earth-sheltered retreat that would be at home on any site—flat or sloping? That flat site shown in Wells's sketch (facing page) requires berming of all sides of the detached smaller unit and on all but the south wall of the main cottage. Note in the floor plan below that this south wall is totally glass, to soak up all the low sun and take the chill off evenings and cool-weather weekends. The cottage also uses a simple sniffer duct system to store every spare Btu of winter sunshine in the floor's massive thermal sandwich.

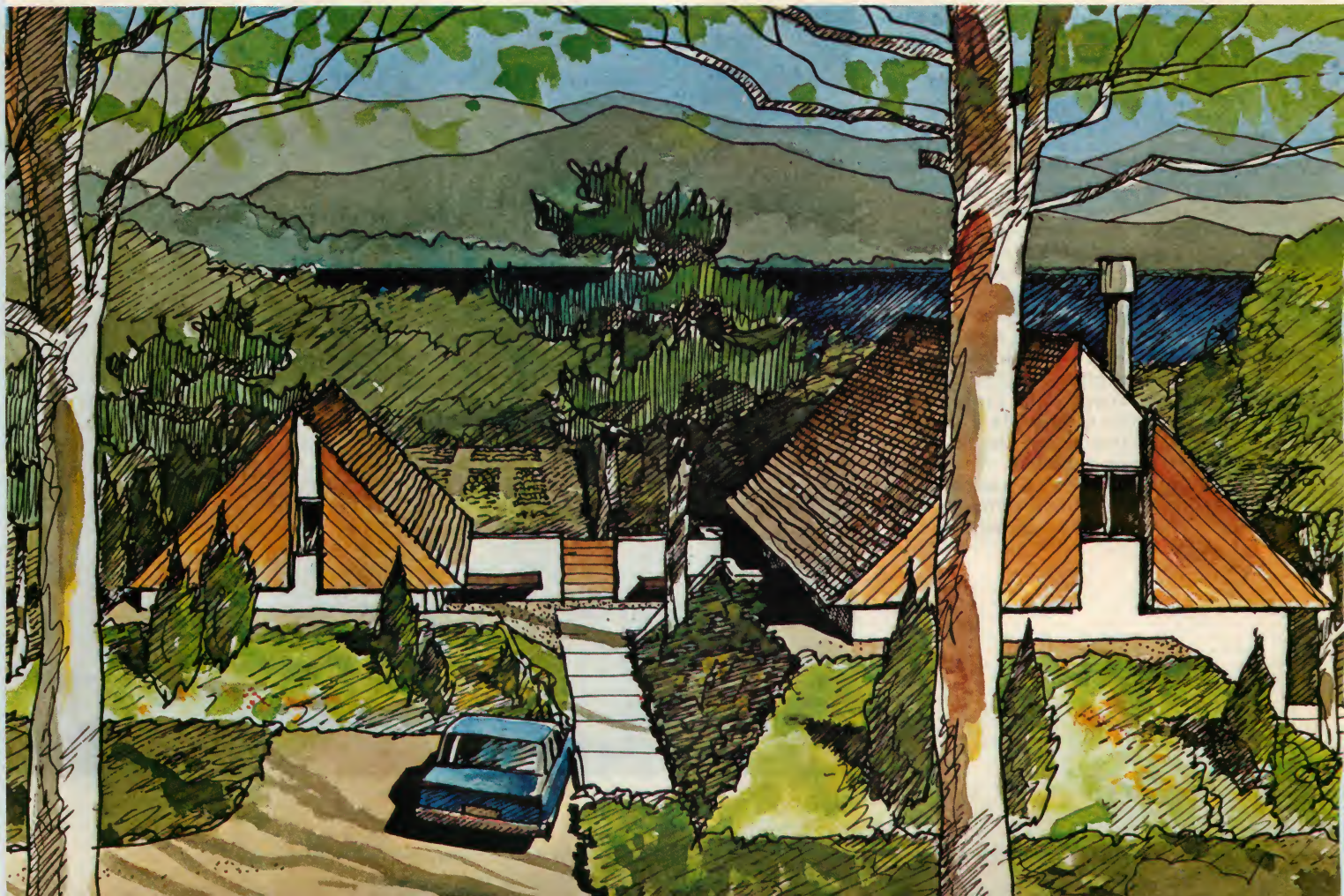
On a sloping site you could just notch the small north structure into the hillside. It can serve as a home office, private study, media room, guest bedroom, shop—or even a garage. Between the two structures is an entry court that could be an amateur landscaper's delight, with angled walls, slopes, and benches. PS



How to order plans for the home you choose

Construction drawings for both of these homes are available directly from the architect. Be sure to specify "High and Dry" or "Low and Bermed." One set is $60. Four sets of the same house (for construction and filing for financing and permits) are $100. Basic specifications are included. Add $3 for postage. Send orders or inquiries to Malcolm Wells, Box 1149, Brewster, Mass. 02631.



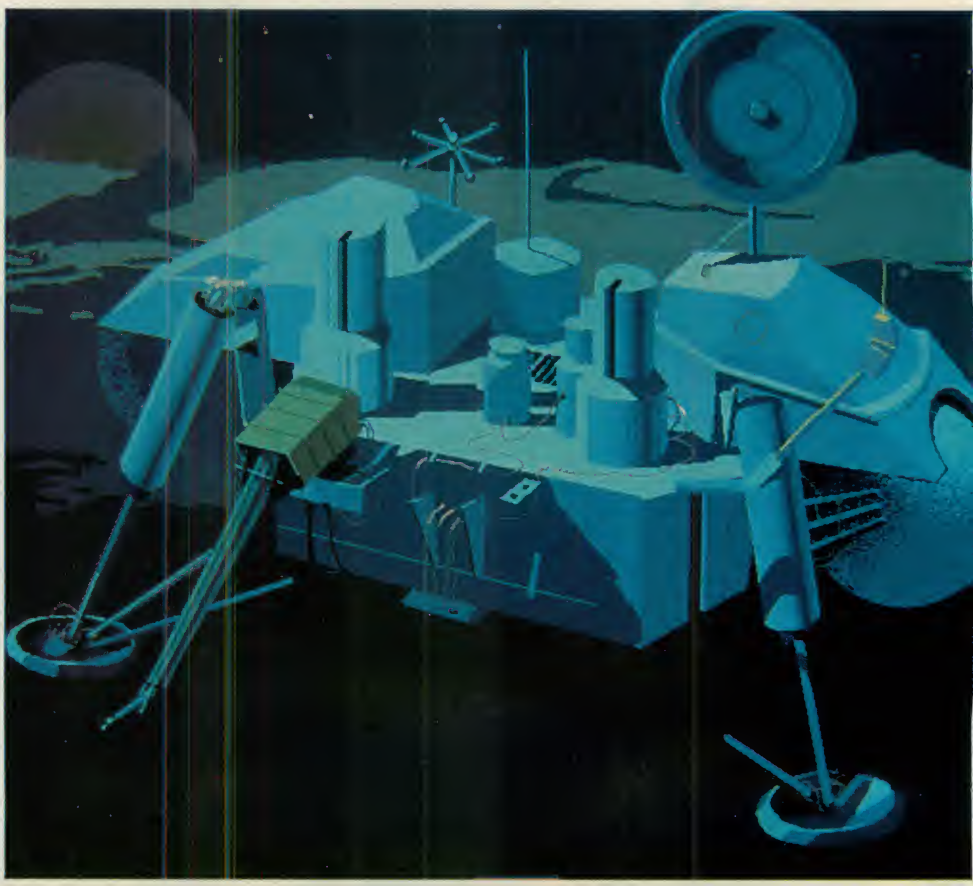


Computerized





Sliding an electronic pen around Flair computer-graphics tablet (above) produces same-size image on a 20-in. video display. Boxes rimming drawing area call up various functions such as a color palette superimposed on part of the screen. Colors are then selected by shifting a screen cursor over the desired color and pressing a control button. Another palette panel provides brush selection. Etching-like sepia portrait (above right) was drawn with fine-point "pen" from brush-selection panel. Airbrush function produced smudgy shading. Viking spacecraft in lunar setting (right) was created by an expert illustrator with no computer background. Spacecraft image is stored on a magnetic floppy disk; reproduction is from a color slide made with a special camera attachment. Gaudy rooster (opposite) was "painted" from colors carefully mixed from a palette of 256. These colors can be mixed from a selection of more than 16 million.



paintbox speeds electronic art

A sophisticated computer-graphics system enables artists to quickly create electronic "paintings" and animated diagrams. The drawing board is an electronic tablet linked to a computer that puts amazing images on a video screen. Simple instructions let beginners become instant electronic artists without learning complex computer codes.

By DAVID SCOTT

"I'm no artist," Gwyn Morgan told me as he slid the puck around the blank drawing board. An irregular, kidney-like shape on a color video monitor recorded his movements. "But now watch this," he said, skidding the puck to the bottom of the board, then back over the shape. Instantly his screen kidney turned pale pink. "Maybe you prefer peacock blue?" he asked. Another quick shuffle and the new color filled the outline.

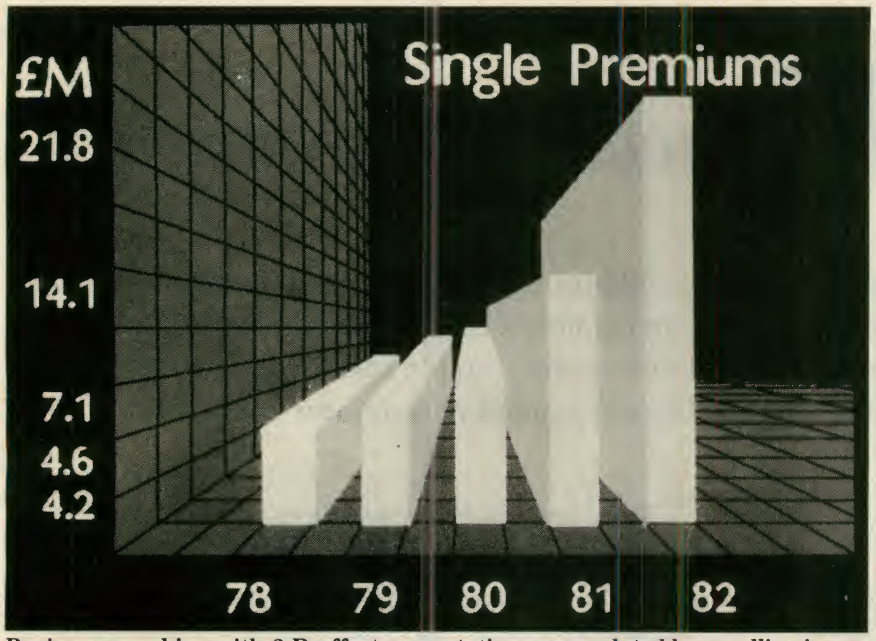
A square appeared alongside the kidney after Morgan put two dots on the screen, marking the diagonal corners. Then came a perfect circle, with two more points on the screen fixing its position and size. An ellipse followed: Three dots established its position, shape, and tilt. These shapes were then changed into different colors.

This was Flair, a "computerized paintbox" created by BBC-TV researchers for video-graphics displays. Flair is a professional-quality computer-graphics system designed to speed the creation of artwork, graphics, lettering, and similar displays. The system has been further developed for commercial use by Logica, a British computer-consulting and software firm (64 Newman St., London W1A 4SE, England), where Morgan is a marketing executive.

"An artist or graphic designer can do practically anything with it," Morgan told me. "You don't need to understand computers any more than does a secretary using a word processor. With just a few minutes' simple instruc-

Continued





Business graphics with 3-D effect are easy with system such as Flair. Presentations are updated by recalling image from memory and altering data.

tion a beginner can produce remarkable designs and effects."

Flair gives an amazing selection of 16 million different colors and gradations. With a wide choice of drawing lines—from pinpoint to broad-brush—you can create impressionist-style paintings, vivid diagrams, cartoons, or dazzling surreal images.

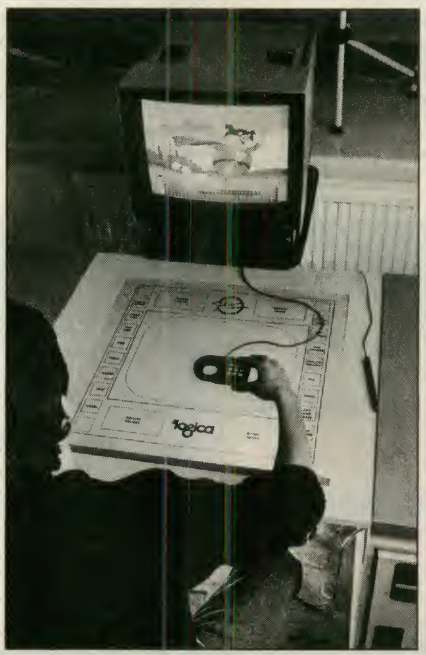
An airbrush facility gives delicate shading. Want to turn a scenic black-and-white photograph into a contrasty tourist poster? You screen the print with a video camera, fill in bold primary colors, and add some text from a keyboard. Morgan showed me how with a glossy calendar photo of a lakeside castle in Switzerland.

"Here are some fun things you can do," Morgan continued. He split the picture down the center and reflected a reverse image of the right side onto the left. "Now we've got two castles," he said. Then he sliced the first shot horizontally and replaced the bottom half with an inversion of the top, giving a playing-card effect.

"Any shape can actually become a brush," Morgan explained, drawing a small flower and coloring it in. He triggered a computer command, and the flower pattern repeated across the screen. Then another command, and the screen filled with flowers.

"We've got animation, too," Morgan said. From a memory disk he called up a prerecorded diagram of a chemical plant. "Fluid" flowed through pipes in all directions.

"You could have step-by-step display of sectors in a pie chart or graph," Morgan pointed out, "or part names on an engineering drawing, or rotating wheels on a machine or vehicle. These action displays are very easy to make and are a natural for business and scientific presentations."



Electronic puck is alternative to pen-like device. Software functions simplify animation of figures on screen.

"Easy" is the operative word for Flair. You sit at a desk with a 20-inch drawing board called a tablet, the same size as the monitor screen facing you. Sliding the puck over the blank white surface produces a same-scale image on the screen.

Here's how it works: A grid of fine wires under the tablet carries bursts of high-frequency pulses that flow endlessly around the closely spaced vertical and horizontal elements. The puck is an antenna that picks up the series of rippling electrostatic waves. Its position on the board determines the arrival time of each burst on the two wires at a particular crossover point. There, the two signals are converted into coordinates by a microprocessor that locates the puck with an accuracy of better than $^{5}/_{1000}$ inch. Some graphic artists prefer an alternative pen-like stylus, which works the same way.

Surrounding the square pallet is a border of two dozen box-shape command "buttons." Some have labels such as DRAW, CIRCLE, ELLIPSE, BOX, HORIZONTAL LINE, and VERTICAL LINE. You slide the puck over the desired button and press its control key; the puck takes on that function when it's returned to the palette.

One of the buttons is labeled MENU; you start with that one. It calls up a list of 11 options such as BRUSHES, PALETTES, TEXT, and DISKETTE. Moving a screen cursor with the puck, you first choose BRUSHES, and a display of tip shapes covers the bottom third of the screen. These range from a fine point and italic nib to large round and square ends. Using the cursor, you select the one you want and draw with it.

Colors come next. Returning to the menu, you pick off PALETTES, and a panel of 256 color blocks (32 by eight) replaces the brush selection at the bottom of the screen. You then choose any block with the cursor. Depending on the brush, you can then fill in shapes, spray any area with airbrush shading, spread a background wash, or make more line drawings.

"Flair has one standard set of colors," Morgan explained, "but there are countless others stored on disks. Or you can make up your own palette, picking colors off any video-displayed picture or chart. You can even create a theme from a single color, with 256 shade gradations of, say, blue or orange. The variations are limitless.

"You've got total creative freedom, and you can afford to try new ideas and have useful accidents that would waste lots of time with conventional methods," Morgan continued. "When you're happy with your work of art, it can be permanently stored on a disk for video replay at any time."

Many TV producers, advertising agencies, and commercial artists all over the world are now using these $50,000 machines on the job. [A number of U.S. firms market similar professional-graphics systems. Time Arts (Glen Ellen, Calif.) has a $6,000 add-on package for the IBM PC that generates similar effects.—Ed.] PS

Plymouth's compact van

Shorter than a full-size station wagon, this remarkable front-drive van handled big loads or seated a large family with ease. Aerodynamic styling, a 2.2-liter four-cylinder engine, and a manual five-speed transmission enabled it to post as much as 25 mpg on the highway, fully loaded.

By JACK KEEBLER
Photo by Greg Sharko

It was about 7 a.m. and still dark enough for headlights. Suddenly I saw the Voyager's high beams glint off what appeared to be a large silver box in the road ahead. I couldn't get into the left lane because I was about to be passed, and there was no room to stop. With only a split second to make a decision, I cut the Voyager's wheel to the right and squeaked by the object. But ahead on the shoulder sat a large truck with a load of industrial-size sheet-metal ducts. Obviously the driver had pulled over to recover one of the wayward members of his load. But no problem: I flicked the wheel to the left, and the Voyager snapped back onto the road.

That was an impressive handling maneuver for Chrysler's latest K-car variant. There were other less-frightening but equally outstanding performances during my 3,000-mile test.

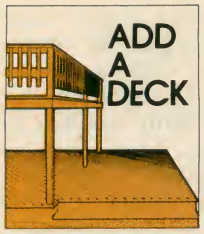
Equipped with the standard 2.2-liter (135-cu.-in.) four and manual five-speed transaxle, the Plymouth Voyager LE model proved to be a surprisingly willing performer. The shift lever moved through its gate smoothly and precisely with only the slightest hint of notchiness. Another positive aspect of the manual setup was the light action of the clutch pedal. It's fortunate that the manual transmission is so easy to use, too, because driving the van on even slightly rolling terrain requires frequent downshifts. The gears are short, and the quick-revving four runs through them eagerly. Chrysler claims the van should get 24 mpg in city driving and 37 on the highway. The PS test vehicle's mileage hovered at 22 mpg in mixed driving; with a full load it dipped to 17.4 during some slippery winter trips into the mountains. Top mileage in highway driving was 25 mpg.

The Voyager's interior was simple yet handsome. The seats were covered with an attractive striped gray corduroy that was warm and comfortable on cold mornings. It also provided just enough grip to keep me in place during lane changes and sharp turns. The test vehicle had the standard five-passenger seating arrangement: two front buckets and a single bench seat in the rear. An optional second bench increases seating capacity to seven people. On the road with just the driver, the Voyager's ride exhibited a truck-like firmness. With four passengers and cargo, the high-rate springs yielded a smoother ride.

In short, I found the Voyager LE to be sporty looking, functional, and economical. And it offers more passenger room and load space than even the biggest station wagon.

One problem: The vehicle did not have the optional rear-window wiper and washer. Consequently, the rear window was quickly obscured on even short drives in wet weather. PS





Patio deck with butcher-block built-ins

A unique patio deck attached to a modest suburban ranch house adds both beauty and utility to the backyard. Roomy benches, comfortable seats, and an ample triangular picnic table grace the deck, and decorative rafters can also serve as hanging racks for outdoor plants.



Steps lead to yard from handsome deck at rear of modest home. Lounge area provides place to sunbathe or gather for wining and dining. Facing page shows layout of deck extras.

By JOSEPH W. ROBICHEAU

If a deck turns out to be just a place to sit or lounge, why bother? I could just as well set a chair out on the grass. That thought ran through my mind as I planned the deck for my backyard. Mine had to offer some useful amenities.

The result is a comfortable lounging area with character. The deck has a triangular table that is easier to get to than most picnic tables. The benches are roomy enough for sunbathers to lie with their arms at their sides.

The deck is open—my backyard isn't obscured by seat backs or railings. The support beams are recessed, giving the effect of reduced mass, and overhead rafters shade outdoor lighting fixtures and support hanging plants.

Construction was straightforward, as you can see from the plans. Some areas needed special attention, however. To build the benches, particular accuracy was needed both in measuring the dimensions for the lumber and especially for the position of each hole (for threaded rods) drilled in the 2×4s used on the seating platforms. Use pressure-treated lumber.

I cut the lumber prior to assembly, with the exception of the top of the long diagonal bench, which I trimmed after I put it together.

To make the triangular table I first drew the table pattern on a large piece of paper (it could have been traced with chalk on a flat concrete surface). Next I laid out precut 2×4s and ⅜-inch plywood spacers on the pattern to be sure each piece was the right length. I then drew a center line from the triangle's apex to the base. Using this line as a guide I drilled 7/16-inch holes through the sides of each 2×4 (with the exception of the piece at the apex). I drilled the exposed surface of the base piece 1½ inches deep so that all of the connecting-rod ends (and nuts) would be recessed.

Continued







The ledger with joist hangers is in place. Black polyethylene sheet was laid to prevent growth of weeds under deck.



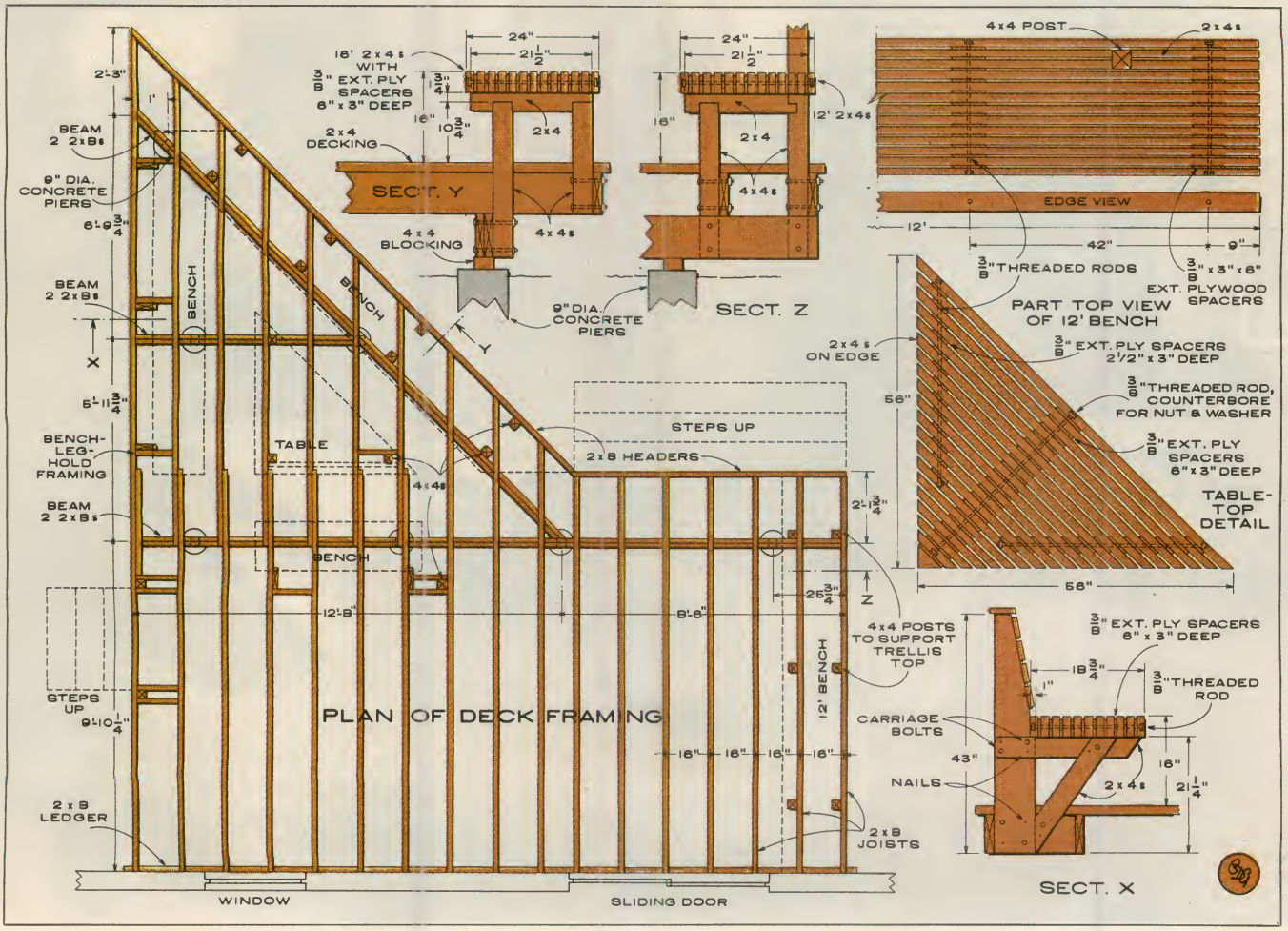
Joists must be level. Penetrating preservative applied to all the trimmed surfaces helps prevent wood deterioration.

I then secured all the 2 × 4s and spacers with a threaded rod by first placing the spacers between the 2 × 4s (including the spacers at both sides of the triangle), then inserting the threaded rod through the center-line holes and tightening the nuts on the rod.

Measuring three inches in from each side of the triangle, I drew a line parallel to the table's edge on each side. The lines stopped at the sixth 2 × 4 from the apex. I disassembled the table and drilled ⅝-inch holes (at a 45-degree angle at the points where the lines indicated) through the side of each 2 × 4 and spacer, aligned all the pieces, inserted the threaded rods, and tightened all the connections. Then I attached the table's apex piece and spacer with countersunk wood screws.

When laying the decking I started from the steps and worked toward the house, then out to the point of the triangular area of the deck. This helped ensure that even the last board was parallel to the house.

The completed deck has become one of the most active parts of my home —just as I'd hoped it would. PS



Make a butcher-block patio stool

By JOSEPH W. ROBICHEAU

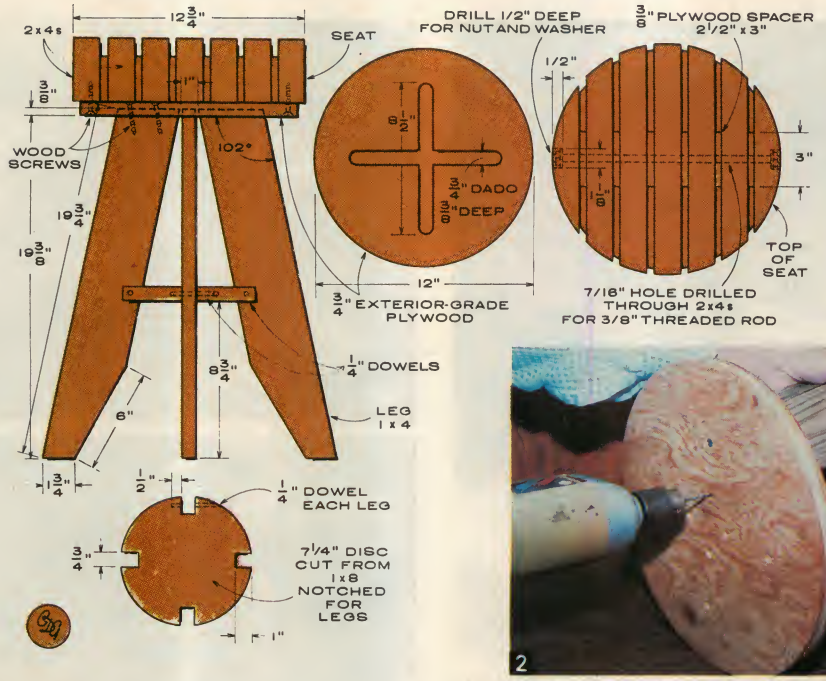
These butcher-block bar stools were designed as companion pieces to the patio deck in the previous article, but they'd enliven any existing deck or outdoor serving area.

To make a stool, first cut a 12-inch-diameter disc out of ¾-in. pieces of exterior plywood. Lay seven short 2×4s (seven to 15 inches long) on edge, separated with ⅜-inch-plywood spacers. Find the center of each of the 2×4s. From these points, measure down from the tops of each a distance of 1¾ inches. Bore a 7/16-inch hole, centered on this mark, through all the pieces, including the spacers. Now assemble the 2×4s and spacers with a threaded rod and nuts. Using a band saw, cut the 2×4 assembly a bit wider than the ply disc.

Use a saber saw at an angle to cut the top edge of the 2×4s. Use a rotary sander with a coarse abrasive disc to smooth the corners, then finish with a belt or orbital sander. Assemble the stool and seat as shown. PS



Attractive butcher-block-like bar stool can be left unfinished or stained to match a deck or other outdoor furniture.







Stool legs fit into the slots on the plywood disc (1). Inside edge of legs must be ½ in. from the center of the disc. Fasten each leg to the plywood disc with two countersunk flathead wood screws (2). Drill ¼-in. hole through the edge of the center reinforcing disc. Apply glue to ¼-by-three-in. dowels, then tap them into place (3) and trim excess with chisel. Secure the stool-top assembly with four countersunk flathead wood screws.









Tiled patio (above), shaded by deciduous trees, is a delightful spot for entertaining. Mortar was spread in small sections with ⅜-in.-square-notched trowel (1). Tile was set with rubber mallet (2) to ensure firm bond. Where butting an adjoining surface, an expansion strip of silicone (Dow 790) was added (3). After approximately 30 days, heavy loads can be installed (4).

Pave a patio with ceramic tile

Ceramic tile has moved outside to the patio. Result: a surface that's more durable and easier to clean than concrete, brick, or flagstone—and it's virtually maintenance-free.

By CHARLES A. MILLER

Picture a patio laid over a plot of brown grass or bald spot in your backyard. Imagine a crowd of friends partying around the barbecue grill. Is there anything missing? How about the work involved in removing the stains and debris from the floor after an especially active get-together?

Patio cleaning and maintenance are a nuisance, but with a ceramic-tile patio, the work can be minimized. That's what the owner of the house shown here found with his tiled patio. The project was sponsored by American Olean Tile Co. (Lansdale, Pa.), makers of the Primitive Ultra Pavers slip-resistant eight-inch-square tile shown.

The 16-by-26-foot patio covers a steel-reinforced concrete slab. To lay the tile, the slab was covered with a latex-modified dry-set mortar (American Olean sanded floor mortar with an acrylic additive). To ensure that the tile would adhere, the mortar was spread onto small sections of the slab and the tile was laid before the mortar skinned over—within 10 to 15 minutes. One section was finished before moving on to another.

The backs of the tiles were "buttered" with mortar and pounded into place with a rubber mallet, ensuring that there were no voids for water to enter and freeze.

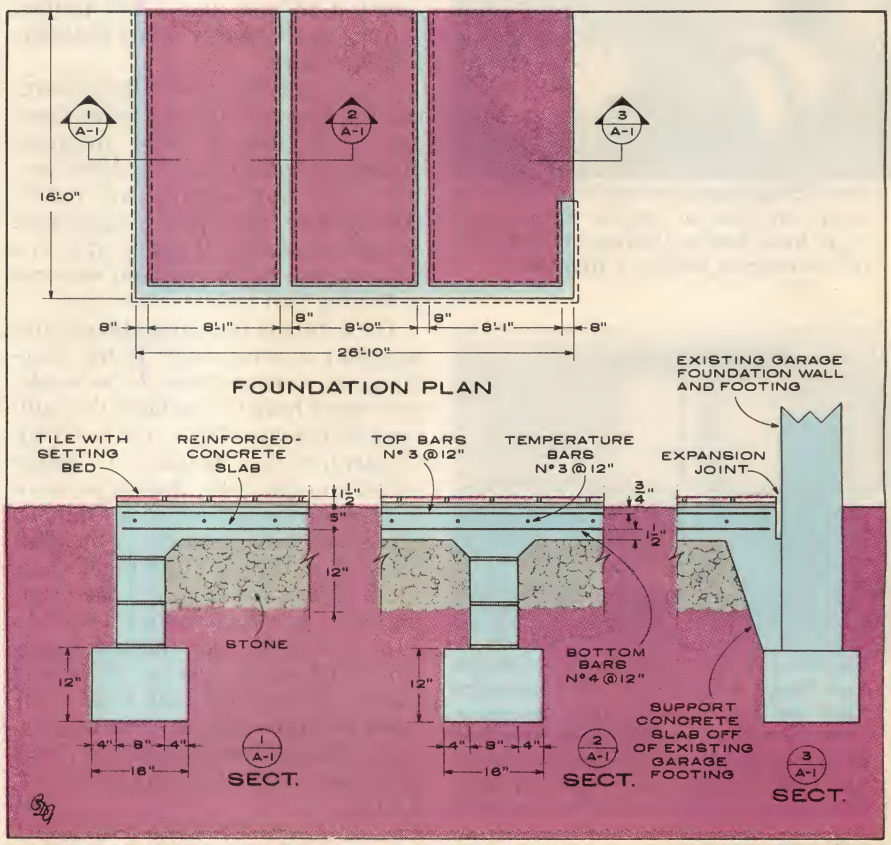
Two days after setting the tile—a minimum length of time—the patio was grouted with American Olean sanded floor grout, a mixture of sand and portland cement. The patio was then covered with canvas tarps to ensure even drying and to prevent the latex in the mortar from being reemulsified. PS



3



4

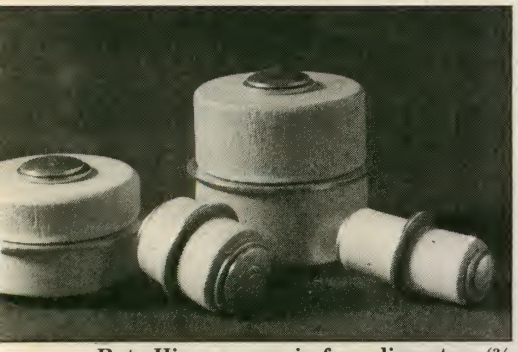


Invisible hinge you glue in place

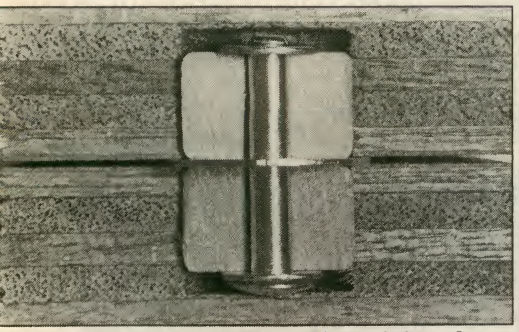
Roto-Hinge is two wooden buttons that rotate on a steel rivet. Installed, it's hidden, which makes it ideal for pivot joints in folding furniture such as this tray table.

By A. J. HAND

Take a look at much of today's best woodworking designs, and you'll see an unmistakable trend: Hardware is out. A clean, all-wood look is in. Of course hardware can't be totally eliminated, but it can be made invisible. That's the idea behind Roto-Hinge, a clever new blind pivot hinge I've been using with excellent results.



Roto-Hinges come in four diameters (⅜ to one in.) and in lengths for 9/16- and ⅜-in. hole depths. Diameters are 0.01 in. oversize to ensure a tight fit.



Cutaway of Roto-Hinge joint shows how hinge is made. Two wooden spindles, stacked on steel rivet, are separated by a washer. Glue holds spindles in place. Flat-bottom holes for hinges are best bored with Forstner bits. Others may penetrate your workpiece.

The photos show how it works. Basically it's a pair of precisely machined wooden buttons stacked on a tubular steel rivet and separated by a metal washer. To use it you simply drill a pair of holes in your mating parts, dab some glue in the holes, tap the hinge into one hole, and tap the other piece onto the other end of the hinge.

After using the hinge in a variety of applications, I'm impressed. Assembly is fast; the joint is strong, smooth, and quiet; and the metal parts of the hinge are zinc-plated for corrosion resistance, so it can be used outdoors. The hinge is made in four diameters, from ⅜ up to a full inch, so it can be adapted to just about any project —from small jewelry boxes to sturdy folding chairs.

Roto-Hinge does have a few idiosyncrasies, however. It can't be removed once it is glued in place. Accurate placement is fairly simple (dowel centers help), but mistakes are nearly fatal. Unlike some other hinges, these are not adjustable. If you're off even a bit with your holes, your only recourse is to plug and redrill.

The nature of the hinge also dictates assembly in some cases. To use Roto-Hinge on a cabinet door, for example, you would have to assemble the cabinet *onto* the door. This could be tricky. Consequently, I think it is better suited to other jobs. X-type joints in folding furniture are a good example. The snack table (shown) is an ideal use for Roto-Hinges. I used them where the legs join and to secure the pivoting top rod to the outer leg assembly. Other suitable uses include rotary joints (in Lazy Susans and all sorts of rollers, for example) and knee joints (such as in articulated desk lamps).

The Roto-Hinge is made by Abra, Inc., Box 1086, Bloomington, Ind. 47402. PS



To set up folding tray table, spread open the legs and insert the two free dowels into the holes in the fixed rod.

Folding tray table

For this sleek tray table, I made the legs of oak and the tray of mahogany. I used an ordinary pine closet pole for the two rods. The plans (right) give all the necessary dimensions, but here are some assembly tips:

Cut and drill all four legs, then attach the inner pair to the crosspiece and fixed rod using glue and clamps.

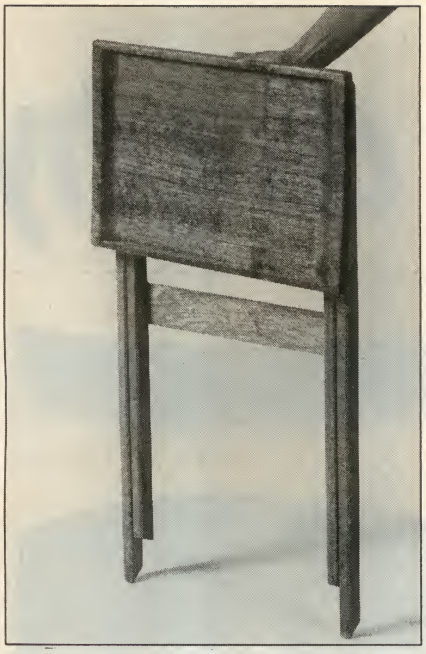
Cut the pivot rod, and drill the ends to accept the Roto-Hinges. Make sure the holes are absolutely concentric with the ends of the pole. Now assemble the outer leg pair by gluing the hinges in place.

After the two leg pairs are assembled, soften the corners with a chamfer bit in a router. Then join the two leg pairs with the Roto-Hinges: Drill the four holes, dab glue into each one, and insert the Roto-Hinges into the holes in the inner pair. Spread the outer pair enough to ease them onto the projecting ends of the hinges.

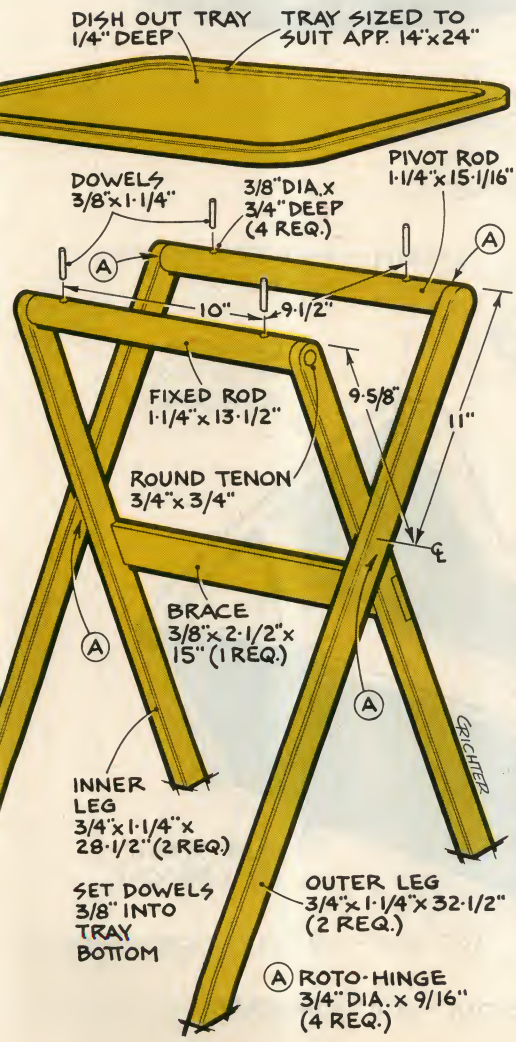
Make your tray. Drill the holes for dowels, but do not put in the dowels at this point. Instead, insert dowel centers in the two back holes, and use them to mark the position of the two dowel holes in the pivot rod. Drill these holes. Temporarily place dowels in them. Place the tray face down, and peg the two dowels in the pivot rod into their holes in the bottom of the tray.

Place dowel centers in the other two holes in the tray. Swing the fixed rod out until it is lined up over the dowel centers. Tap the rod down onto the centers to mark their positions, and drill the holes in the fixed rod. Now glue all four dowels into the holes in the tray, and glue the two back ones into the pivot rod as well. Do not glue the two front dowels into the fixed rod.

That's it, except for finishing.



To store, lift the two front dowels out of their holes and fold the table into a neat package just two in. thick.



Thermal shutters lock out the heat (and intruders)

These ingenious thermal shutters halve the heat loss of even double-glazed windows and provide up to four times the insulation of plain glass, the maker claims. The secret is hollow PVC louvers with two internal layers of air pockets, each a quarter-inch thick. The extruded panels are profiled to overlap, and sealing strips or brushes at the contact joints and around the outer edges trap air behind the closed assembly.

The vertical slats are fixed between the top and bottom tracks, and are linked by tapes so you can adjust the pivot angle. Pushing or pulling on the first slat opens or closes the screen. There are no mechanical or electrical controls to jam or burn out, and the louvers don't rattle or flap in the breeze like Venetian blinds or similar window coverings.

The British-made Guardia shutters also perform a security function. When closed, the rigid panels can be locked in place by a horizontal metal bar fixed between opposite wall cleats screwed to the window frame. The solid barrier then guards against theft or vandalism.—*David Scott*

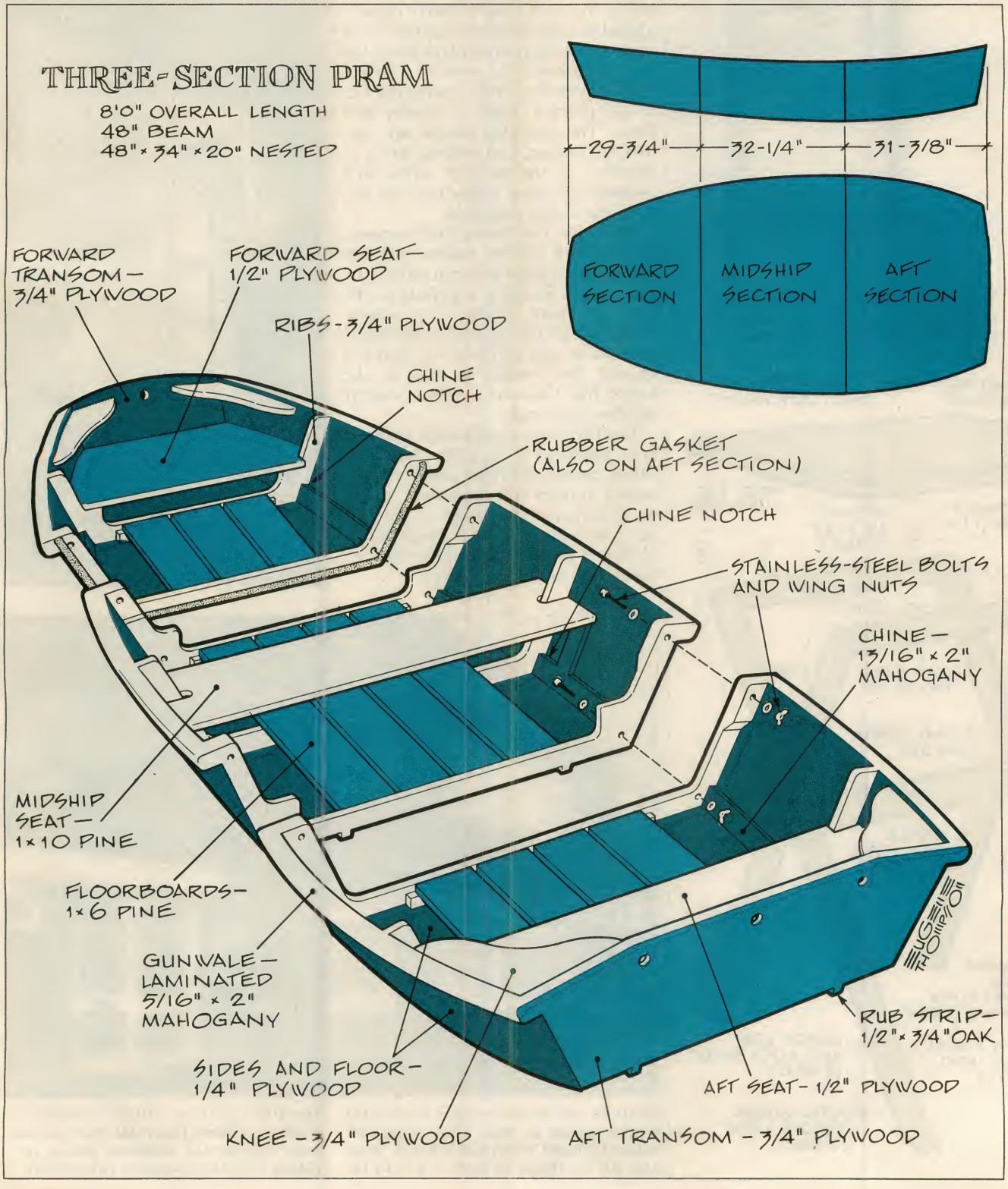




Shutters are fixed between horizontal tracks (photo at top). They slide and rotate by hand. Each slat is 5.2 in. wide and 0.7 in. thick. Length is cut to fit.

The PVC sections will fit any door or window (above). Each slat overlaps and seals against the adjacent panel, providing effective weather protection.

Nesting dinghy



you can build

Designer Othon's sectional dinghy is as seaworthy as it is handsome. However, it's a job for an expert carpenter.



By ULYSSES OTHON
Illustration by Eugene Thompson

My dinghy is a serious boat for a serious woodworker. I designed it to be the best plywood boat possible in an eight-foot size yet compact enough to stow. It's strong, rows well, and has a nautical look that should please the eye of any sailor.

Nested, it needs only a 48-by-34-by-20-inch space, so it fits in some car trunks and all station wagons. It's also a practical dinghy for many yachts that don't have the deck space to carry a full-size boat.

Almost anyone can launch this boat. The heaviest section weighs 30 pounds (total weight is about 70 pounds), and it takes about five minutes to bolt the mating sections together.

But it's not a boat anyone can build. A boat that simple would look too much like a box for my taste.

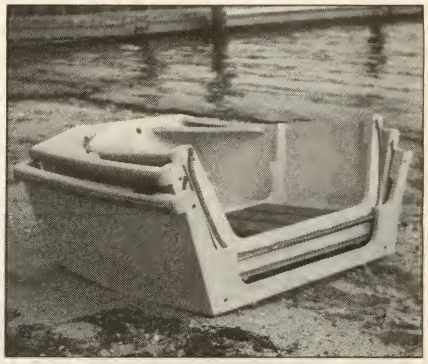
To assemble the boat properly, you need two jigs. One is basically a slotted box that supports ribs and transoms while you attach sides, chines, bottom, and gunwales. You can build this jig with scrap lumber. However, the trueness of the finished boat depends greatly on the jig's accuracy.

The other jig is basically a board wedged between upper and lower rungs of a ladder laid on its side. The jig aids in bending and gluing the laminated gunwale—the most troublesome member to make. This sheer clamp spans almost the arc of a circle. It keeps the sides curved while providing longitudinal strength and serving as a rub rail.

Another construction challenge is bending the interior chines into a continuous fair curve down the length of the boat. For this critical step you need two helpers. After pressing the chines into rib notches (see drawing), you tension the chine by looping a rope under and around the boat jig.

Two-part epoxy paint acts as both seal and finish—no fiberglass is needed. The paint shrinks only slightly upon curing, so it serves as a filler for small spaces where parts haven't fitted together tightly enough. It also fills in end-grain pores and hardens the surface.

With reasonable care, a well-built nesting dinghy will give many years of trouble-free service. My own boat, shown above, is 20 years old and looks almost new. PS

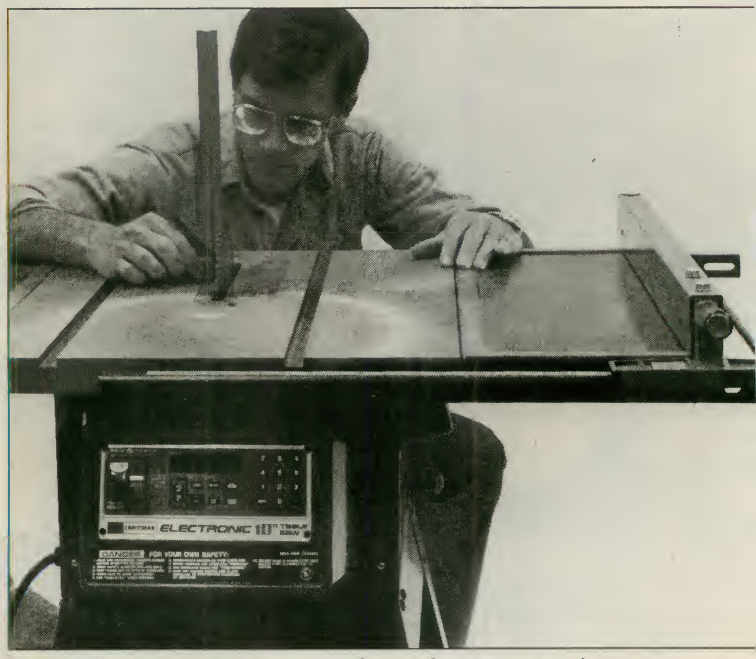


Stacking dinghy sections (above) stow in a four-by-three-ft. space. Bolted together (top), the eight-ft.-long boat has room for three persons and can accept a small outboard engine. Plans and complete instructions for both the jigs and dinghy are $8.50 from Ulysses Othon, 14 Maplewood St., Glen Head, N.Y. 11545. Full-size patterns for ribs, transoms, and knees are $5 extra. The prices include postage and handling.

World's first electronic

PS exclusive test

After entering the home shop a few years back in portable power tools such as drills and jigsaws, electronic circuits have finally made it into full-size stationary tools. Along the way they have brought extremely accurate, easy-to-read digital displays, the convenience of motorized controls, and the promise of even more magic to come.



If you take time to set up properly, perfect accuracy is possible from both radial-arm and table saws. Author spent four hours getting table saw ready, two hours on radial-arm.

By A. J. HAND
Photos by the author

With the whir of a motor, the blade on the table saw came to life. No, it didn't spin. It tilted. As it did so, red digital readouts flashed on a control panel, racing upward from zero degrees. When the readout hit 45 degrees, the whirring stopped. Then it resumed, but now the blade began to rise from its slot in the table. Again the numbers flashed, this time reading out the height of the blade as it rose. When the motor finally stopped, the blade height read 1.375 inches. The electronic-power-tool revolution had taken another step forward.

The scene was my shop, where I had just spent the better part of a day setting up two brand-new tools from Sears. These tools, the Craftsman electronic table and radial saws, are the first of their kind in the world. And now that I finally had them set up and calibrated, I was anxious to find out just how good these new stationary tools were. I had a lot of questions.

Would the digital readouts be more accurate and easier to read than conventional scales and pointers? Would the motorized controls be faster and more convenient than hand cranks, or are they just another gimmick that could break down? Would the computerized controls really give the precision advertised (depth to 0.005 inch, angles to zero degrees)? If so, would the mechanical parts of the saws have the precision and integrity to match the electronics? And finally, would these tools really be worth their $690 price tags?

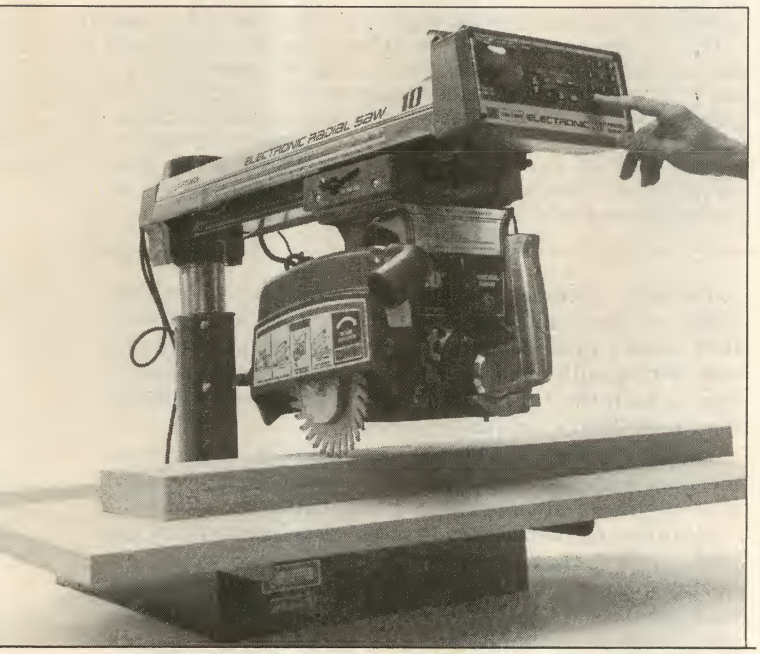
After working with both saws for a few weeks and talking with the people who made them, I can report that, with a few exceptions, the answers to all of these questions are positive. Let's get specific.

Table saw

The basic guts of this saw are almost identical to those of the Sears saw I have been running in my shop for the past 10 years. The big difference? There are no handwheels to adjust blade elevation and tilt. Instead there's a push-button control panel with a digital display (see box). The panel lets you adjust blade height and tilt in two ways. First, you can punch in the exact settings you want—height in inches, tilt in degrees—and gear motors built into the saw will automatically adjust the blade to those settings. This is the way you'll be working most of the time. Or you can "jog" the blade into any position you want by pressing the JOG buttons on the control panel. Generally you use this feature to adjust the saw for calibration. To do this, you jog the blade to its fully raised position. Then, using a square as a reference, you jog the blade over until it is perpendicular to the table. Jog the blade down until it is flush with the table top and press the CAL (calibrate) button. The saw is now set.

How accurate are the settings? Perfect, I found, if your square is square. I proved this by tilting the blade over to 45 degrees and crosscutting a piece of two-inch stock. When

table and radial saws



Controls on radial-arm saw are up front where they're easy to see, easy to work. Here a dado blade has been zeroed, and author calibrates a −0.375 elevation for a ⅜-in. dado cut.

I placed the two miters face to face they produced a perfect right-angle joint.

Part of the secret of this accuracy is that the saw always makes adjustments the same way—it always moves to its depth setting in an upward direction. If the blade is at two inches and you set it to drop one inch, it will actually run slightly below one inch, then reverse and come back up to your setting. This compensates for any "slop" in the mechanical parts of the system and ensures perfect repeatability.

The small gear motors that carry out your instructions work slowly. It takes about 40 seconds to run from zero to 45 degrees, and elevation speeds are around eight seconds per inch. On the surface, that's not as fast as the handwheels on my old saw. But when you punch in 30 degrees on the electronic saw, you get 30 degrees. You don't have to make a test cut, check it, and perhaps readjust as you usually do with mechanical adjustments and scales. And while the blade is tilting, you can turn to other tasks, something you can't do while cranking a handwheel. Speaking of which, after a few years of use, the handwheels on my old saw got pretty tough to turn. The threads in the adjustment screws under the table tend to load up with pitch and dust, and it's not fun going in there to clean them. Would the gear motors be able to cope with that kind of strain?

To find out, I coated the threads with heavy grease, then packed them with sawdust and ran the blade up and down 10 times in a row without a rest. The gear motor got warm but never faltered. Then I talked about the durability of the saw with Burt Wiley, product manager for the Sears tools.

My big fear was that one of these motors would give out in the middle of a job, leaving me helpless. "Gear motors have caused no problems on test saws we've run in special boxes designed to trap sawdust," Wiley told me.

What about the electronics? Could dust foul it up? And what about the problem of static electricity that occasionally sends computers into fits? "All these problems have been checked out," said Wiley. "We even ran test saws in humidity chambers to simulate the humid conditions in the typical basement shop."

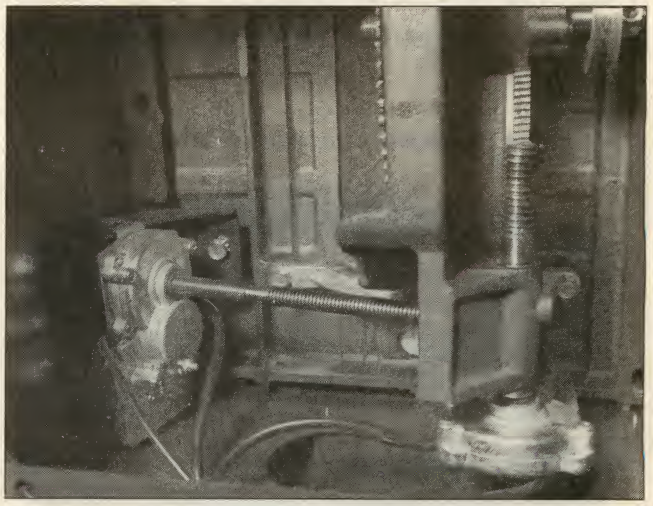
Personally, I'm impressed. Complaints? The surface of the table is somewhat roughly machined, but you can quickly cure that with a belt sander. And the rip fence on this saw is just not up to the quality of the rest of the tool. Now that my tests are complete, I'm going to junk the stock fence and replace it with the Biesemeyer T Square fence (see an upcoming PS article) I've been using on my old Sears saw.

Radial-arm saw

This tool is just as impressive as the table saw. It also features a large control panel with an easy-to-read digital display. The readout shows blade elevation to the nearest 0.005 inch and bevel and miter settings to the nearest 0.5 degree. If you've ever tried to read the little protractor-type angle scales on most radial saws, you'll understand how impressive that 0.5-degree capability can be. And what you see is what you get.

To check this out I decided on a severe test: compound miter cuts for a six-sided hopper joint box. This is extremely tricky work in which the geometry of bevels and miters

Continued



Gear motors under table saw turn pitch and elevation screws; circuitry counts blade height, bevel measurements.

Controlling the electronic table saw



The control panel of the table saw features digital display, control keys directly beneath the display, number keys at right, and master and saw-motor switches at left. Turning on the master switch activates the electronics; turning on both switches activates the saw motor.

Press the ELEV key, and the display shows present blade elevation. Pressing the upper JOG key slowly raises the blade; pressing the lower JOG key lowers it. Tapping either key changes elevation in 0.005-inch increments. To set the blade to a desired elevation, punch in that elevation on the number keys at right, and then press the ACT key.

Press BEVEL, and the display shows the blade's current bevel angle. Pressing the upper JOG key tilts the blade slowly to the left; the lower JOG key tilts it right. Tap these keys, and the blade tilts in 0.5-degree increments. To achieve a desired angle, use the number and ACT keys.

The CAL/ENTER key calibrates the saw when the blade is level with and perpendicular to the table. It's also used for programming the saw to set both bevel and elevation automatically in sequence. The CLEAR/STOP key clears the display and stops any programmed motion.

The electronic circuitry loses its memory if the saw is unplugged or if power is cut off, so it's a good idea to leave the saw at zero elevation and bevel at the end of a day's work. Then if power goes off, you can recalibrate simply by pressing the CAL/ENTER key.

interrelates, and even tiny errors multiply into big ones. This job usually requires a series of test cuts, tedious readjustments, and more test cuts. But with the electronic radial I just looked up the proper miter and bevel settings in a table, set the saw according to those numbers, and made my cuts. The parts fit together almost perfectly.

Most of this accuracy is due to the electronic readouts, but the mechanical integrity of the saw also plays a big part. I've been using a conventional Craftsman radial-arm saw for many years, but no matter how carefully I adjusted it, there was always a bit of side play in the arm. There's none of that in this new saw, however.

Any black marks? While I was torture testing the table saw's gear motors, I did the same with the single gear motor that raises the radial's arm. I sent it up four inches and down four inches time after time without rest. The motor got warm, and finally, on the ninth trip up, the overload switch kicked open. That's a lot of raising and lowering, more than you'd ever be likely to need on any job I can think of. And the motor was reset and ready to go in approximately 10 minutes. Still, I thought you'd like to know.

Conclusions: Both of these saws offer exceptional convenience, accuracy, and precision. Any setup you achieve today you can duplicate exactly, next week or next year. Both saws run smooth and true. If set up properly and used with quality blades, either can produce silky-smooth cuts in both the rip and crosscut modes. Are they worth the price? That's for you to decide.

The future: Remarkable as these saws are, they are not the final phase of electronic-tool development at Sears. Now engineers are working on expanding the electronic capabilities of both saws. Possible developments in the works include digital readouts for both miter gauge and rip fence on the table saw and digital rip and crosscut readouts on the radial-arm. If and when these improvements become available, will you be able to add them to existing electronic saws?

"The miter gauge could be retrofitted," said Wiley. "But the other new features would require all-new control panels." PS

PS ARTICLES ON ELECTRONIC TOOLS

"The Microprocessor Revolution Hits Your Workshop," Nov. '80; "Computerized Drill Press," July '81; "Electronic Jigsaws," April '82; "Electronic Drills," July '82; "Portable Power Goes Electronic," March '84.

Table-saw specifications

Hp	Blade	Rip cap.	Thickness cap. @ 90	Thickness cap. @ 45	Table size (with wings)	Arbor
1	10 in.	24 in.	3⅜ in.	2¼ in.	30 by 27 in.	⅝ in.

Radial-arm-saw specifications

Hp	Blade	Rip cap.	Crosscut cap.	Thickness cap. @ 90	Thickness cap. @ 45	Table size	Arbor
1½	10 in.	26 in.	15½ in.	3 in.	2¼ in.	27½ by 40 in.	⅝ in.

Controlling the electronic radial-arm saw



The control panel of the radial-arm saw is similar to that of the table saw. Press the ELEV key, and the display shows blade elevation to the nearest 0.005 inch. Pressing the upper JOG key slowly raises the blade; pressing the lower JOG key lowers it.

To set the blade to a desired elevation, punch in that elevation on the number keys, and then press ACT. To cut to a certain depth, jog blade down until it just touches your stock. Press the REF/SET key to zero the display. Then press the desired depth of cut and the MINUS key. Finally, press ACT, and the blade will lower to the proper height.

Pressing the BEVEL key displays the blade's current bevel setting. To set bevels, tilt the saw motor by hand while watching the bevel display. Tighten the bevel lock on the motor when you reach the desired bevel angle.

To set miters, press the MITER key. Miter angle will be displayed. Swing the arm right or left until the display shows the desired angle. Then lock the arm.

Beginner's guide to

auto repainting



Is repainting a car too big a job for a backyard mechanic? The author pointed a spray gun at his own car to find out. He discovered that with the proper equipment and some expert advice, almost any handy person can get good results with few mistakes.

By JACK KEEBLER
Photos by Greg Sharko

Repaint my own car? Originally I thought I might have a pro do the job, and I'd simply document the procedure from the sidelines. But after some research I realized that the best insights would be gained by doing the job myself. I already owned a compressor and had previously done minor repainting and body-repair work. Besides, it looked as if it might even be fun.

I found that a beginner can do a competent job provided that: (1) he or she has some previous experience with spray painting and (2) his or her expectations are realistic.

Preparation

Naturally I first bumped out all of the dents and dings in my Volkswagen Beetle. Fortunately all of the surface imperfections were easily filled with body putty. But this article isn't on body-pounding, so I won't go into these preparations in any detail. Many auto-supply stores now sell

Continued





Most of the chrome, antennas, wipers, and badges must be removed before the paint is applied. Sometimes it may be easier to mask these specific pieces of hardware.



Big Sears Craftsman sander-grinder comes in handy for knocking down the cracked and peeling paint to bare metal. Wear safety glasses when sanding or grinding body panels.

do-it-yourself body-working kits and other material such as tubes of body putty, and local libraries have lots of books on body-working techniques.

Next I applied a wax-and-grease remover (Du Pont Prep-Sol) on all of the painted surfaces. This was to remove contaminants that might have prevented the new paint from adhering properly. If any of your original paint is cracked, bubbled, or peeling, you'll have to sand or strip the area down to a bare, stable surface. I used a large electric disc sander-grinder to smooth out the really rough spots.

Some experts I spoke with insisted that a good paint job can't be executed on anything but bare metal. To remove the paint from an entire vehicle you'd need a liquid paint remover. But unless the original finish is in truly sorry shape, try to stay away from the strippers.

The next big step was removing all of the chrome hardware and bright trim. (You may find that it's easier to mask a particular piece of brightwork rather than remove it.) I then wet-sanded the car with 240-, 360-, and then 400-grit paper to give the primer something to bite. The windows were masked with 3M masking paper and fresh tape. You can use newspaper if you're on a tight budget, but you run the risk of the print bleeding onto your new paint job. Don't try to make do with an aged roll of masking tape. I found that old tape is brittle, won't stick properly, and allows paint to creep underneath onto the wrong surface.

I sprayed the entire car with Platinum Gray 30 S primer-surfacer from Du Pont. Primers provide a coarse surface to which the topcoats can adhere. A primer-surfacer not only primes the surface, it also fills minor surface imperfections such as sanding or grinding scratches. My compressor is a small, single-horsepower unit from Sears. Make sure the compressor you use, whether rented or your own, can supply a minimum of three cubic feet per minute (cfm) at 35 pounds per square inch (psi). Also make sure you have enough air hose (35 to 50 feet) to move completely around the car. I didn't. During my second coat I had to move the compressor, and it accidentally became unplugged. I didn't notice the pressure drop until poor paint flow showed up on my car.

Thoroughly clean the work area before you begin. After the body work, sanding, and primer application, I swept carefully, then covered the entire floor with masking paper to keep the dust at bay. (You may want to do all of the body preparation in your driveway to keep the contamination out of your garage or spray area, especially if you intend to shoot enamel.)

Before I started spraying I practiced shooting paint at an old fender and a cardboard box. This gave me a chance to set the air- and fluid-adjustment screws on the back of the spray gun.

When I finally applied the topcoats, I held the gun about eight to 10 inches from the panel. I was told you shouldn't arc or tilt the gun. If you do, it will deliver too much paint to the center of the panel section and too little at the ends of your stroke. I also made sure each stroke of paint overlapped the previous stroke by 50 percent. Finally, if you're about average height or less, you may want to position a step stool in the work area so you can reach the top of the car or truck.

Painting procedure

Two topcoat paint types are generally considered best for beginners: acrylic lacquer and acrylic enamel. (The solvent for lacquer is referred to as thinner. The solvent for enamel is called a reducer.)

If you repaint a car the original color, as I did, you'll

[*Continued on page 148*]

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BUILT FORD TOUGH.

Ford

Video trickery

shrinks camera-recorder combo

Pop a full-size Beta cassette in Sony's new camera-recorder, and tape for up to one hour on a battery charge. Nonstandard recording techniques—using one instead of two recording heads, for example—produce tapes for any standard Beta-format deck.



By JOHN FREE
Photo by Greg Sharko

When I pushed the red RECORD button, a solenoid clicked, and the shoe-box-size VCR resting on my shoulder began whirring. The 5.5-pound machine, Sony's one-piece Betamovie camcorder, is a vast improvement in comfort over 10-to-25-pound VCRs I've slung on my shoulder with a strap. There's also a welcome absence of dangling cords between VCR and camera. A new ½-inch pickup tube, with an f/1.2 lens with macro-focus and power zoom, is extremely sensitive in low light.

I found that Betamovie was easy to use. That's just what the people who brought you Betamax, the first practical home VCR, had in mind. "Betamovie is the easiest way to enter the world of home-movie recording," says Neil Vander Dusse, president of Sony Consumer Products. "It's smaller, lighter, easier to use, and less intimidating to the consumer than any other portable video system," he claims.

The $1,596 Betamovie is a cousin to expensive broadcast-quality camcorders used by TV stations. It's the first all-in-one entry in a portable-VCR race that now includes JVC's Videomovie, a four-pound camcorder with 20-minute VHS mini-cassettes.

Sony felt that its machine should use standard Beta cassettes, capable of recording up to three hours and 20 minutes on one L-830, with one hour per battery charge. To shrink Betamovie to its compact five-by-8¾-by-14-inch overall size, Sony used electronic and mechanical trickery.

These video tricks provide a camcorder that uses nonstandard recording techniques but cassettes that can be popped into any Beta-format VCR for playback. One Betamovie failing is that the machines—so far—can only record, so an electronic viewfinder can't be included for instant playback.

Most VCRs have two recording heads on opposite sides of a spinning metal drum. During one-half of the drum revolution, one field (half) of a TV picture is recorded on a long, slanted path. As the drum completes a revolution, the other video head captures the second half of the picture on an adjacent track.

But compared with conventional Beta-format decks, the head drum in a Betamovie is 40 percent smaller (about 1.8 in.). Also, a Betamovie has a *single* recording head that spins twice as fast as in ordinary decks. Betamovie's final trick for achieving Beta-format compatibility: Tape is wrapped 300 degrees around the drum instead of the usual 180 degrees.

But as I discovered by playing my Betamovie productions onto a projection-TV screen, the nonstandard recording technique doesn't sacrifice picture quality. Actually, Betamovie's tricky recording method achieves a higher "writing" speed than most VCRs, with superior fidelity.

Squinting through the optical viewfinder and balancing Betamovie on your shoulder, I discovered, can be tiring. One accessory, a U-shape shoulder brace, might ease recording. As you might expect, Sony offers lots of Betamovie accessories. PS

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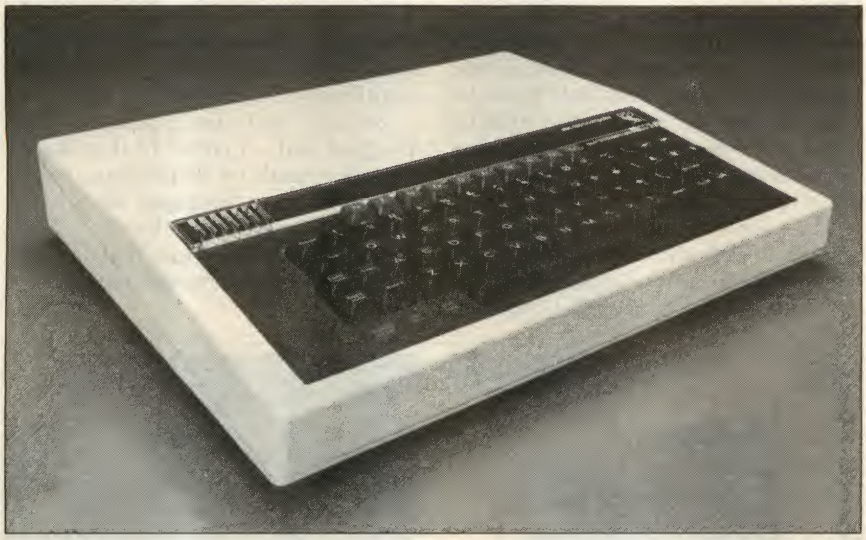
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COMPUTER REVIEW

The expandable Acorn

The Acorn is a very powerful computer. Its secret is unusual flexibility in both hardware and software. It can use more than one microprocessor at a time, communicate with up to 100 other Acorns in a network, and use several languages to execute one program.



By DAVID SCOTT

LONDON

The BBC has adopted it for a series of TV computer-literacy programs. The British government is buying thousands of them for use in the country's schools. Indeed, all over England (including my house) the Acorn personal computer has become a success. And now under a new name—the British Broadcasting Corp. Microcomputer—it's available in the U.S. (Acorn Computers Corp., 400 Unicorn Park Dr., Woburn, Mass. 01801).

The $995 Acorn uses a 6502 microprocessor and has 32K of user memory, flexible graphics capabilities, and a multitude of interfaces. That price also includes word-processing software, speech synthesis, disk-drive-control circuitry, and an Econet hookup for computer-to-computer communications. Econet enables over 100 machines to be linked by ordinary telephone lines to share expensive resources such as a printer or disk.

Other facilities include an audio-cassette interface, a ROM cartridge socket for additional plug-in programs, a parallel printer connection (Centronics-type), and a serial interface for adding other peripheral equipment such as a modem.

There's also the "Tube." That's a direct-memory-access interface that lets the system work with a second add-on internal microprocessor for faster operation and more flexibility. For example, an expansion board will be available that uses a second 6502 microprocessor for controlling another 64K of RAM. And another board allows the system to use programs written for the CP/M disk-operating system. Future plans are for a 16-bit processor running under UNIX, an operating system designed for multi-user operation and large memory arrays.

Although the machine has no built-in video screen, it has output sockets for a conventional TV set or a video monitor. There are eight selectable color-graphic modes with a wide range of formats. One problem, however, is that the data to be displayed are temporarily held in the user-RAM area. So the higher the graphics resolution you choose (requiring larger amounts of memory for storage), the less space you'll have for your program.

BASIC plus

A special structured form of BASIC is the principal language. Stored in 16K of ROM, it has all the attributes of Microsoft BASIC plus additional commands for Acorn operations.

The Acorn also has automatic multi-language abilities. You can switch from BASIC to Pascal, FORTH, or LISP with a simple keyboard command, or give the command from within a program. That allows you to write a program using a mixture of languages. When the program runs, the machine instantly switches from one language to another as needed for execution. Also, for assembly-language programming, a built-in 16K ROM is available for your use. It contains prewritten routines for such things as displaying data on the screen, printing, and disk operations.

A standard keyboard with an electric feel smoothed my transition from typewriter to word processor. Along the top of the keyboard is a row of 10 keys that can be set for often-used program commands such as "print," "list," or "run."

My only complaint is the location of the BREAK key on the keyboard: It's much too easy to hit by mistake. When you do, you restart the whole system and erase your work.

For other goofs, there are 43 different error messages that explain what you've done wrong. And before you do something really catastrophic—such as deleting the wrong section of a text—you hear a warning bleep.

For me, the Acorn's let-it-grow-with-you approach to computing has great appeal. I like the idea of a machine that doesn't stretch me unreasonably but gives me flexibility as my skills increase. PS

Your electric ovens
—how to keep 'em all cooking

Today's home may have a microwave oven, a convection oven, or a combination oven, as well as a conventional model. Regular inspection and maintenance will keep them performing well and safely. If one should fail, you can probably repair it yourself.

By EVAN POWELL

A few years ago your kitchen probably had one oven—tucked into the range. Today, if a voice from the kitchen says, "The oven isn't working," your first response may be: "Which oven?" Many kitchens have a microwave oven (built-in or countertop), a convection oven—or perhaps a combination appliance—in addition to the old standby conventional model.

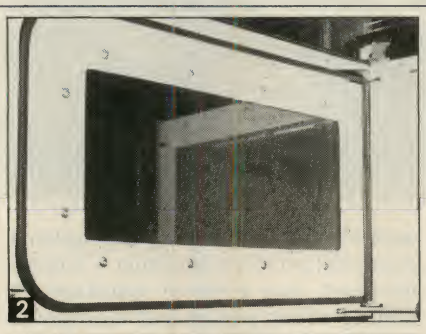
As with all appliances, electric ovens perform best when they're kept up to specs, and occasionally they'll need repairs. You can gain your apprenticeship while tuning your ovens for safe operation and top performance; if they should fail later, you will then be ready to put them back into cooking order. [For how to repair range-top burners and gas ovens, see "Readying Your Range," PS, Dec. '79].

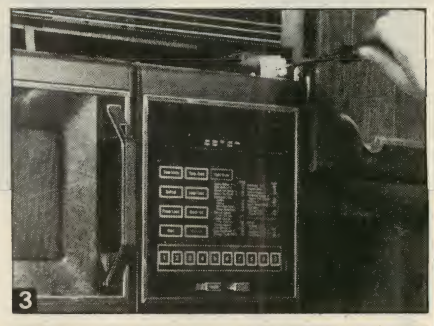
The only tools you need are an inexpensive volt-ohmmeter (VOM) and common hand tools, including perhaps a ¼-inch nut driver or socket. And you might want a leak-test meter if you have a microwave oven. Low-cost (about $18) meters are available from appliance stores. These are not professional-quality instruments but will indicate significant microwave leakage.

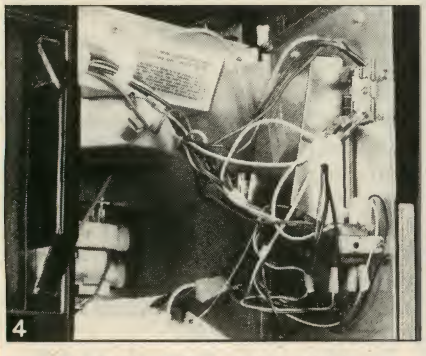
Be sure that the appliance is unplugged and all power to it is turned off before making inspections (except for microwave leakage) or repairs. Rely on your eyes as well as your VOM in diagnosing problems. When replacing any electrical component, remove

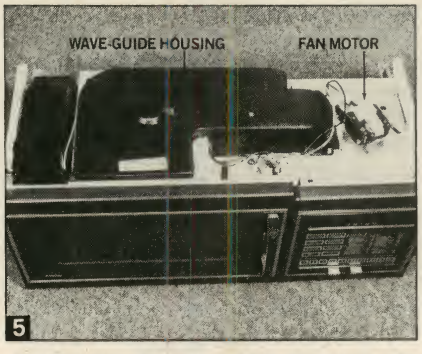
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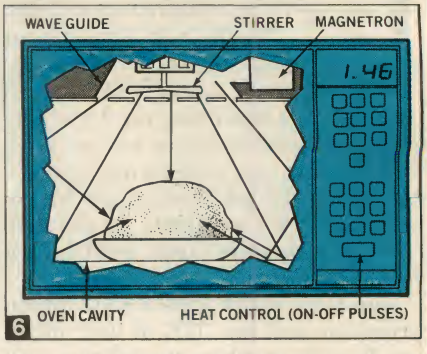












Microwave leakage of significant levels can be detected by passing a low-cost radio-frequency meter (1) around the perimeter of the door while the oven is on. Door gasket on most microwave ovens (2) is replaced by separating inner and outer door panels (usually held by four screws near corners); screws around middle hold glass in place. Use only the replacement gasket recommended by the manufacturer. Mounting screws that anchor built-in microwave ovens in place (3) are usually behind trim panels. Turn off power before removing panels. After loosening mounting screws, slide the unit forward a few inches to get to the control-panel screws. Loosen these to reach controls. Do-it-yourself servicing (4) is limited to controls, wiring, and switches. (Door-interlock switches are located behind each latch.) Magnetron, wave guide, and housing (5) should be repaired *only* by a professional. How microwave ovens work (6): A magnetic field generated within the magnetron changes polarity millions of times each second. The energy is guided into the oven cavity and is absorbed directly and indirectly by the food. The constant polarity shift creates heat by friction as the molecules of food rub together. Only the food heats up.



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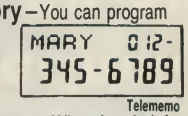
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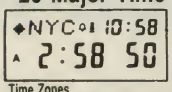
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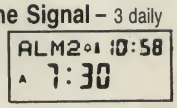
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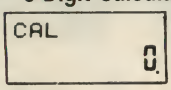
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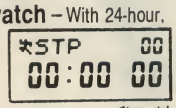
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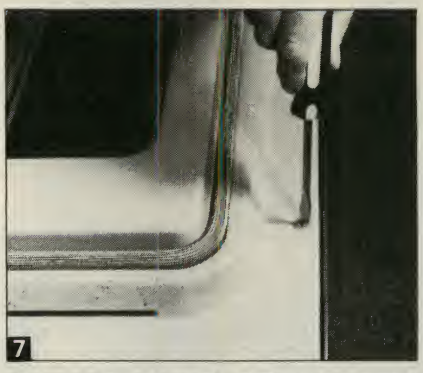
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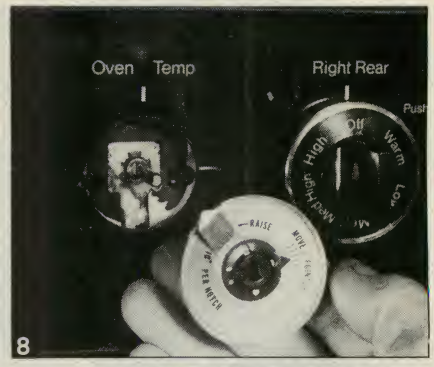
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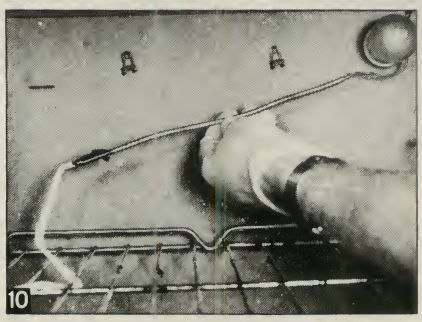
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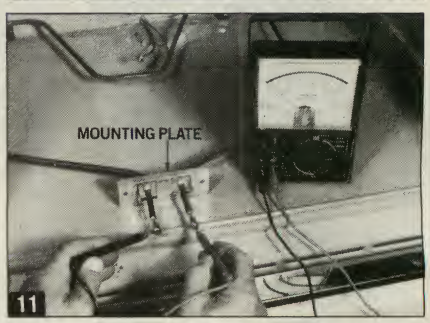
© 1984 ON THE RUN

Your electric ovens









The door of a conventional oven may need adjustment (7): Loosen screws holding inner and outer panels, twist gently to shape, and retighten. Order new gasket by range model number. Temperature can be recalibrated (8) by moving ring behind control knob or by turning screw behind knob; make only small compensations. Thermostat is reached by removing rear panel (9). If terminals and wiring are discolored, replace thermostat. Check contacts with VOM: It should indicate zero when thermostat is turned on and range is unplugged. Thermostat-sensing tube (10) passes through liner into oven. When replacing it, tape a string to the old tube, pull it out, and pull new one through with string. (Wear rubber gloves to handle tube.) To test elements (11), loosen mounting plate and pull element forward. Inspect, then test with a VOM set to R X 1—it should read 15 to 30 ohms. Also test ground with meter set to highest scale. How conventional oven works (12): Oven cavity is semi-sealed and insulated, and has heating elements at the top and the bottom.

the wires from the old part one at a time, attaching them to the new one as you go along. Markings on the component and the appliance's wiring diagram will help you double-check to see that they are in the right place.

Microwave maintenance

"You should never touch your microwave oven. You can't do anything to repair it yourself." You've probably heard something like that, but don't take such warnings seriously. Although repairs in the magnetron and wave-guide areas (see diagram) *must* be left to qualified technicians, problems rarely occur with those components. You can and should do the most important job of all—monitoring the oven to be sure it is operating safely.

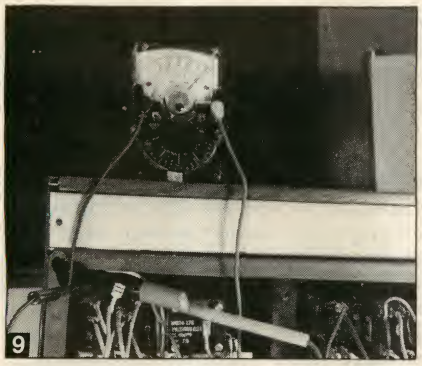
A sagging door, a cracked or out-of-place gasket, a light that won't come on—those are minor problems on a conventional oven but big ones on a microwave. Door seals on a standard oven only keep heat in, but on a microwave they keep the microwave energy from getting outside the oven—the only condition that poses a hazard. The lamp that won't light could be just a burned-out bulb. But it could be a defective interlock switch, and that could allow the oven to operate with the door open. Such problems must be remedied, and the appliance should not be used until they are. [For tips on installing a range-hood microwave, see "Shop Talk" in this issue.]

In addition to inspecting and repairing any problems with the door, you can replace the timer and controls on most microwaves (see caption). If you replace the part a wire at a time, you should have no problem.

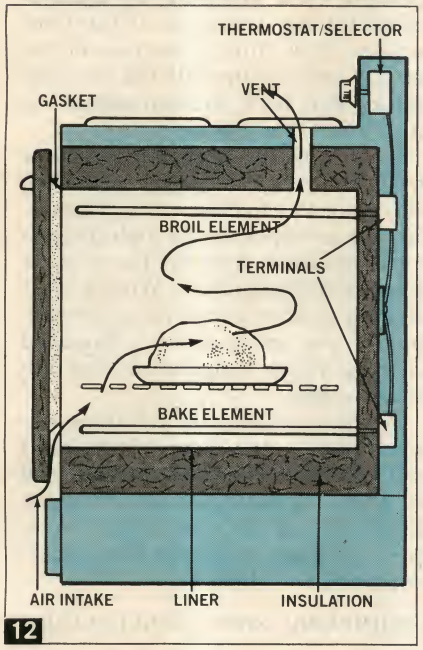
Inside the conventional oven

Whether it's in a free-standing range, at eye level above the cook top, or built into a wall or cabinet, a conventional oven must maintain close temperature control throughout the compartment to bake properly. The amount and placement of heat, the air circulation within the oven cavity, and even the reflectivity of the oven liner can make a big difference in baking performance.

The preliminary checks are visual. First, look at the vent. On most in-range ovens you'll find it beneath a rear burner. The vent must be unob-



9



12

structed; I've found many of them blocked by food spills and broken glass. (If you use burner covers on your range top, be sure to remove the one covering the vent when you use the oven. By the same token if you cover that burner liner with foil, be sure to leave the hole in the center open.) Built-in ovens are usually vented through the front.

Next, check the oven-door gasket. If it is brittle, cracked, or pulled loose, it should be replaced. Then close the oven door. (If it is a lift-off door, be certain that it is seated completely on the hinges.) It should seal evenly around the perimeter, lightly compressing the gasket; turn on the oven light when you check for gaps.

If the door does not seal across the top, the problem could be a broken door spring or worn hinge. Replacement springs and hinges are available. Most doors have coil springs that extend from the hinge down to the oven frame at floor level. You can reach these by removing the lower panel or drawer. If they are not in that location, the inner and outer panels of the door

Continued

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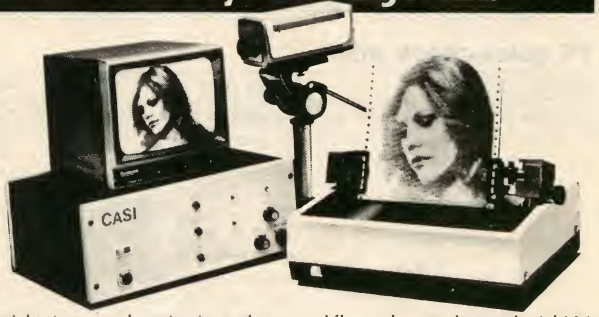
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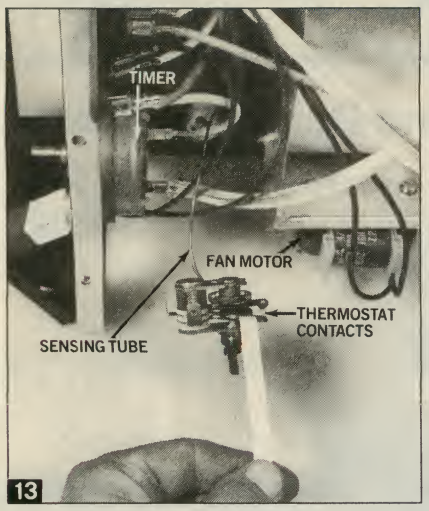
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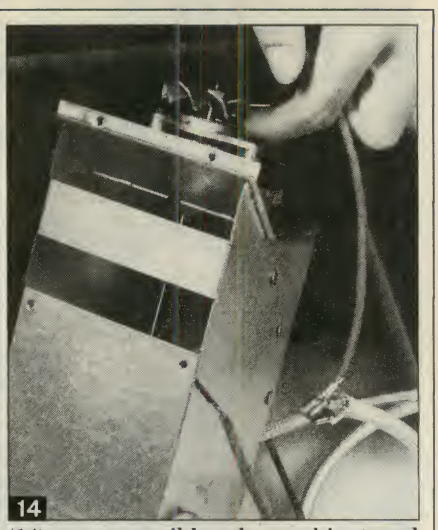
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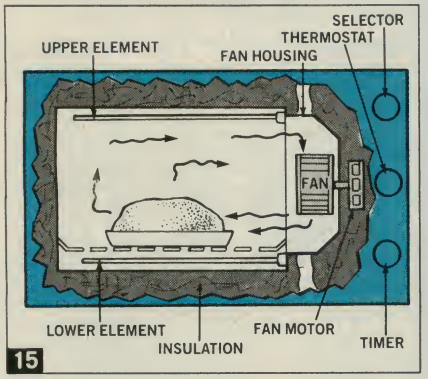
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Convection ovens often have thermostats with open-type contacts, which can become fouled. To clean (13), pull a strip of white bond paper through contacts. Control components and fan (14) are accessible when cabinet and side insulation are removed. To reach control-panel-mounting screws you might need to remove front panel. Primary fan is located within housing; external fan (shown) cools motor and components. When reinstalling, keep insulation away from fan parts. A convection oven (15) works like a conventional electric oven but also has a fan to circulate air within the cavity. (Thus it should be called a *forced*-convection oven.) Fan keeps temperatures more consistent than in a conventional oven and reduces baking time. Fan, controlled by selector, operates only in "convection cook" mode; both upper and lower elements can be energized at once. Fan can be mounted above the upper element or in a duct on side (as shown), pulling hot air in from the top and recirculating it out the bottom.

PS quick-check table

Symptom	Possible cause	Remedy
Microwave ovens (caution: do not service components within housing; contains charged capacitors)		
Won't work	No power to oven	Plug table lamp into receptacle; check fuse or breaker if it fails to light
	Open fuse or circuit breaker in oven (not in all models)	Check with VOM; replace fuse or reset breaker
	Defective timer or touch panel	Check with VOM; repair as necessary
Noisy	Foreign object caught in fan	Inspect and remove
	Metal panels loose	Inspect and repair
	Loose or damaged fan blade	Inspect and tighten
	Filter clogged (not on all models)	Check and clean; see owner's manual
Door not fitting properly (do not use oven)	Damaged or misadjusted latch	Inspect, repair, or adjust as necessary
	Hinges broken or misadjusted	Inspect and adjust; check complete seal
	Damaged or broken seals	Replace and readjust
Conventional ovens		
Oven won't heat (bake and broil elements inoperative)	Fuse blown or circuit breaker tripped	Check with VOM; replace fuse or reset breaker
	Timer set to "off" position	Set timer correctly; see owner's manual
	Selector switch defective	Check with VOM; replace if no continuity
	Thermostat open	Check with VOM; replace if no continuity
One element operates	Wire to other element broken	Inspect and repair (using high-temp materials)
	Selector switch defective	Check with VOM; replace if open
Oven temperature incorrect	Thermostat calibration incorrect	Check with accurate thermometer; adjust if off by more than 15 degrees
	Rack or oven bottom not in position	Check owner's manual; install correctly
	Foil or rack blocking airflow	Remove foil
	Restricted vent flue	Inspect and clear as necessary
Convection ovens (most checks above apply; other possibilities below)		
Oven won't heat	No power to oven	See under "Microwave ovens"
	Open wire, switch, or thermostat	Check with VOM; replace or repair if no continuity reading in "on" positions
Oven heats slowly or unevenly	Blocked or restricted airflow	Check for binding fan or blocked duct opening
	Fan motor inoperative	Check for continuity with VOM at R X 100; replace motor if open

will have to be separated to reach the springs. If the door fails to make contact at either top corner, you should adjust the inner and outer panel (see photo).

Only after the door closes properly can you check the temperature calibration. First, see that the thermostat-sensing tube inside the oven is in its retaining clips and not touching the side of the oven or the heating element. Place a good-quality oven thermometer in the center of the oven, then let the oven cycle for about 30 minutes before taking a reading. If the temperature is within 15 degrees of the setting, performance should be satisfactory. If it isn't, you can adjust the calibration (see caption).

Because of the high temperatures involved, ovens use special insulation and connectors in their wiring circuits. You can get replacement high-temperature materials from appliance-parts stores and distributors. Wiring must be of no smaller gauge than the original. If you must splice a damaged wire, use a high-temperature wire nut; do not solder.

Heating components are accessible from inside the oven. But most switches are reached from the rear of the range. To get to them, first remove the knobs and their mounting screws from the front; then the rear access panel can be removed.

Countering convection troubles

Most convection ovens are countertop models, though some new ranges have built-in convection ovens instead of the conventional type. The only significant difference between conventional and convection ovens is that the latter have fans to circulate air within the cavity (see diagram). However, convection ovens can also cook without the fan. The fan is controlled by the selector switch and operates only when "convection cook" is selected.

A broken wire or open motor winding can stop the fan, but the most common problem is jamming. That can occur when part of a broken utensil or even large food particles lodge in the blades. I have also found fan motors stopped by out-of-place insulation. A quick examination, first with your eyes and then with a VOM, should isolate any such problem. Other tuning and maintenance can be handled just as for a conventional oven.

Combination ovens? They're really no different from their single-function counterparts. When servicing them you should concentrate only on the problem area, trouble-shooting that part just as you would if it were a single-mode oven. PS

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Ion Fountain	540,000	NO
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Now You Can Own A Super-BackChair For Less THan $70 And It's **Better** Than The Ones Sold For $149.95!



No more scrunching up while sitting at your computer. The Super-BackChair gives you comfort — and good posture.

This is the chair that at last distributes your weight between your lower back and your legs. You can sit all day in perfect comfort.

Whether you're typing (it's the perfect height for standard typing-tables), sitting at a desk, playing TV games, or just relaxing, you'll find — perhaps for the first time in years — that you can sit all day without feeling fatigued.

What a boon if you have occasional backaches. Often, back and neck troubles stem from sitting in a slumped or uncomfortable position. The Super-BackChair not only lets you sit comfortably, hour after hour; it actually improves your posture.

Maybe you never thought of a chair as a way to have you feeling and looking like a million. The whole family will be fighting to sit in the Super-BackChair. Offices are moving out their old-fashioned, tiring secretarial chairs and replacing them with these 'chairs of tomorrow.' The Super-BackChair is handsome hardwood, richly upholstered in plush. As we said, only New Horizons' tremendous buying-power makes it possible for you to own this chair for an unbelievable **$69.95**. Tens of thousands of back chairs, not as luxurious as the Super-BackChair, have been sold for as much as $149.95 —and they're worth it.





Work all day with no back strain — your weight is distributed the way it should be.

Money-Back Guarantee, Of Course

Your Super-BackChair will come to you in a special shipper-box. Use any ordinary screwdriver to attach the plush pads, and watch the line form as family and guests wait their turn to sit on it.

We want you to give your Super-BackChair a real tryout before deciding whether or not you want to keep it. So use it for one full month. If you decide you aren't thrilled with your Super-BackChair, send it back and we'll refund every cent. Our opinion, though, is that you probably will want more of them. If you want to save even more money, order two or three right now, and save $6.00 to $10.00 on each one.

The Super BackChair: **$69.95**; two for **$59.95** each, or three for **$49.95** each. (Plus $7.95 for shipping each.)

DEEP RELIEF FOR:

Muscle Pain ★ Backache ★ Tennis Elbow ★ Bursitis ★ Arthritis

THE INFRALUX

Sends Real Infra-Red Soothing Heat Deep Into Sore Muscles And Nerve Endings

Doctors have known the therapeutic value of infra-red heat for years. Now Infralux makes it possible for you to carry relief with you.

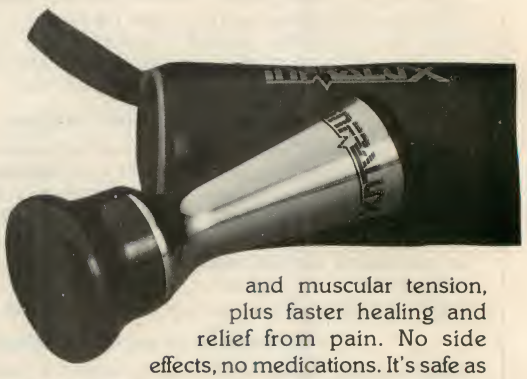
No bigger than a small flashlight, Infralux goes anywhere in its handsome vinyl bag. Plug it into any wall outlet and touch it where you hurt. (It even works through clothing.)

You can't hurt yourself. Drugs and medications have a limit, but you can use Infralux safely as often as you like.

Here's exactly what it does:

Infralux dilates blood vessels. It increases local cell metabolism. It removes accumulated fluids and toxins faster than they normally would be gone. It soothes irritated nerves. Result? reduction of inflammation and muscular tension, plus faster healing and relief from pain. No side effects, no medications. It's safe as a warm bath. Don't confuse this with dangerous X-ray, sunlamp, or microwave therapy. Infralux can only help — it can't hurt you. You'll feel better fast, sometimes literally in seconds, almost always within 5 minutes.





The Infralux Infra-Red Pain Reliever; **$39.95.** (Plus $3.75 for shipping)

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Use the Super-BackChair or the Infralux for one full month. If either doesn't please you, send it back undamaged for a full refund.

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For information call: (201) 370-1234 or send check or money order. (Be sure to add shipping cost.)

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European Doctors and Therapists Use this Amazing Device to Help Blocked Sinuses, Muscle Pains and Poor Circulation

THE SOUND MASSAGER

"Oscillates" The Tissues as Deep as 2¼" Below the Skin

Yes! This is the same famous instrument that was awarded the gold medallion at the International Inventors Exhibition. **Yes!** Testimonials report relief from such ailments as blocked sinuses in **seconds.**

But we make not one single claim for it.

Why? Because it hasn't been "scientifically" proved in the United States.

What We Can Do

No, we don't make any medical claims for the **Sound Massager.** But if it doesn't give you the same incredible fast relief we'll describe to you in the next few paragraphs, send it back and we'll refund every cent you paid for it.

The **Sound Massager** has been approved for use in the United States for treatment of stress and strain due to overexertion, which means other approvals may be in sight soon. Meanwhile you can be the first to enjoy the benefits of the **Sound Massager** at the new low price!

Price Cut In Half!

In Europe, where medical approval is complete — and until recently in this country — The **Sound Massager** has been priced at $300. Thousands of satisfied users bought it at that price.

Now, Only New Horizons Can Bring You the **Sound Massager For Half The Original Price: $149.95!**

How The Sound Massager Works

The **Sound Massager** produces oscillations in the 100 to 10,000 Hz range — some 600,000 oscillations per minute.

Other massage appliances produce, at best, 7,000 oscillations per minute. In one second the **Sound Massager** equals the oscillations it takes standard old—fashioned massagers an entire minute to give you.

According to some users, this means more help in one second than a standard massager can give in one minute. Unlike some hard-ended, bruising instruments, the **Sound Massager** can't damage delicate tissues.

How Short-Wave Therapy Works

As far back as the 1920s, scientists such as Schereschewsky (U.S.A.), Schliephake and Essan (Germany), and Stilbock (Austria) found that short waves in the 10.3 meter range could be used to treat sciatica, lumbago, various inflamations and even headaches.



Dr. Schliephake carried his experiments to include sound waves, especially those within the range of human hearing, which he called Intra—Sound, working under water at Jena in the early 1930s (because water conducts sound better than air). Later, he placed sound plates directly against the human body.

After World War II, experimentation intensified. Swiss, Austrian, and German clinics began using a prototype instrument in 1953, obtaining near-miraculous results. More than 30 years — and hundreds of improvements later — the **Sound Massager** at last is available to you, direct.



Try It For Relief From...

Aside from blocked sinuses, owners tell of quick relief for strains, blows, bruises (including those inflicted by other "massagers"), and sports injuries.

Older folks, with poor circulation, report it helps their hands and feet, which always feel cold. Still others use **Sound Massager** for muscle spasms, nervous tension, or just as an invigorating daily tone-up.

Arthritis? Try it. This is one of the uses we can't claim, but we wouldn't suggest you try it if we expected to have to refund your money.

Other Features

The **Sound Massager** has two massage heads. Plug it into any 120-volt outlet. You can adjust it through the Intensity Control as well as the on/off switch. The cord is exandable, coiled.

Warranty is for one year, but the **Sound Massager** is built to give you years and years of dependable use.

The Sound Massager ***$149.95.*** *Add $2.75 for shipping.*

WE ABSOLUTELY GUARANTEE!

Use the **Sound Massager** one full month. If you don't agree with us (and European doctors) that it brings help for the ailments we've described, send it back undamaged for a full refund.

For fast delivery on credit card orders call toll-free 24 hours a day, 7 days a week:

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Housepower Clinic

By EVAN POWELL

Beating summer humidity

On hot, muggy days moisture in the air can affect a person's comfort even more than the temperature. Air conditioning helps by removing water vapor as it lowers the temperature. But if your home isn't air-conditioned or if you have to endure days when the temperature is too low to permit the air conditioner to wring humidity from the air, the effect can be brutal indeed.

There are some inexpensive solutions that can dramatically improve your comfort. But first it's important to know just how humid your home is. Hygrometers—small meters sold in many hardware and discount stores—can be a good indicator of humidity, but the most accurate device is a sling psychrometer. Compare the humidity inside with readings taken outdoors.

Humidity differences greater than 10 percent usually can be controlled. How? By stopping moisture at its source. For instance, in crawl spaces over exposed earth you can cover the soil with polyethylene film. It's not necessary to tape the film or to seal it at the edges. Another source of humidity can be vapor penetrating through walls or concrete floors that have no vapor barrier. Walls can be sealed from the inside by coating them with a fibrous mineral compound.

Q&A Ground-fault problems

I'm building a workshop in my basement so I can work on my automobile. A neighbor recently installed safety circuit breakers for his basement and outdoor circuits, but the breaker on the basement circuit kept tripping; he finally had to reinstall the old breaker. Is it worthwhile to install these devices, or should I just use a conventional circuit breaker?

Bill Foley, San Antonio, Texas

By all means use ground-fault-interrupter (GFI) circuit breakers. In a new circuit install the GFI as the circuit breaker in the panel, just as your friend did. In older circuits you can install a combination GFI-receptacle as the first receptacle in the line (usually this will be the one closest to the electrical panel).

GFIs are important for basement, outdoor, and bathroom circuits because they interrupt the circuit if there is any current leakage, however small. When properly installed they shut off power before you can receive a harmful shock. That's probably the reason your neighbor had trouble. If there is any current leakage in the circuit, either through a tool or a faulty circuit (this is especially likely in an outdoor circuit if the receptacle becomes damp), the GFI will trip.

Filtering a fridge

I have a problem with the ice maker in my Gibson refrigerator. Black and



brown particles from the waterline find their way into the strainer where the line connects, and sometimes into the ice itself. A friend told me that I should install a water filter, but somebody else said that such filters were breeding grounds for bacteria and didn't advise it. What do you recommend for this problem?

Joe N. Allan, W. Palm Beach, Fla.

Most manufacturers market a water-filter kit to combat this problem. You also can install a conventional domestic-water filter. If your refrigerator is near the sink, install a charcoal filter with a Tee fitting in the supply line—one side of the Tee to feed the ice maker and the other to supply a special faucet or the cold-water faucet at your sink. If you're having this much trouble with the ice maker, the sediment is probably finding its way into your drinking water as well. Conventional filters are not necessarily intended for sediment, but they will do a good job of handling a small amount. If there is so much that it overloads the filter, you may have to install a secondary sediment filter.

Try to find the source of the sediment. It could come from the waterlines in your house, especially if they are galvanized pipe. Another source could be particles in a well. Check carefully—you may be able to reduce or eliminate the sediment altogether.

Water filters generally contain bacteria only when improperly maintained. Most manufacturers recommend that you replace the filter element every 12 months. I personally prefer a six-month interval.

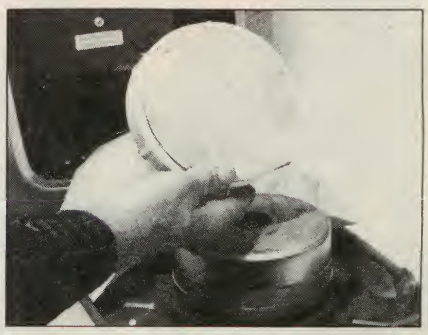
Vacuum tuneup

My Sears canister vacuum has gradually lost its suction power, to the extent that it is now almost useless. I was planning to replace the fan-and-motor unit until I checked the price of the new part. My present unit still sounds and runs smooth. Is there anything I could have missed?

Robert Jenkins, Detroit, Mich.

There is a secondary filter on almost all vacuum cleaners, and it is often overlooked. On some machines it's obvious (see photo) once you look—it may be attached to or near the fan intake. Just remove it and clean it (most are washable plastic foam), and the lost suction will be restored. More than that, a functioning filter restores the protection that keeps excessive abrasive dust from the fan-motor bearings.

If you haven't already done so, you should also check your hose for foreign objects that can cause a blockage. Typically these are toothpicks, small nails, or wires that become lodged diagonally in the hose and catch lint going by. If you find an obstruction, insert a garden hose into the end opposite the power unit (pushing it in the direction opposite airflow) and gently nudge out the blockage.



Got a home-equipment problem? Write to Evan Powell/ Housepower Clinic, Chestnut Mountain, Rte. 1, Box 322A, Travelers Rest, S.C. 29690. Give appliance make and model number. Unpublished questions cannot be answered by mail.

And what to do if they're not.

Here's a tip from Mr. Goodwrench on how to check shock absorbers. "Just push down on a corner of your car. Hard. Two or three times. Release. The car should rebound and then stop if your shock is O.K. Repeat on all four corners.



CUPPED TIRE

25,000 "Even the finest shock absorbers wear. After 25,000 miles, you may notice other symptoms. Here are things to watch for. If your car leans after changing direction. Or keeps bouncing after a bump. Or if your tires show cupping or have unusual wear at any one spot you should do the shock test.



"Also look at each shock absorber. Is it leaking oil? Is a mounting broken? Is the shock dented? Are bushings worn?"

Good shocks mean more comfortable driving. So if you need shock absorbers, see Mr. Goodwrench. He has the right training. GM training. And the right parts. Genuine GM Blue Line shock absorbers with a lifetime limited warranty for as long as you own your General Motors car or light-duty truck. You'll find him at participating independent GM dealers who sell Chevrolets, Pontiacs, Oldsmobiles, Buicks, Cadillacs, GMC and Chevy trucks.



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LET'S GET IT TOGETHER...BUCKLE UP.

wrench

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MAKE YOUR DREAM COME TRUE.

Over 6,000 Mercury dealers worldwide are ready to show you what the 1984 Merc dream machines can do.

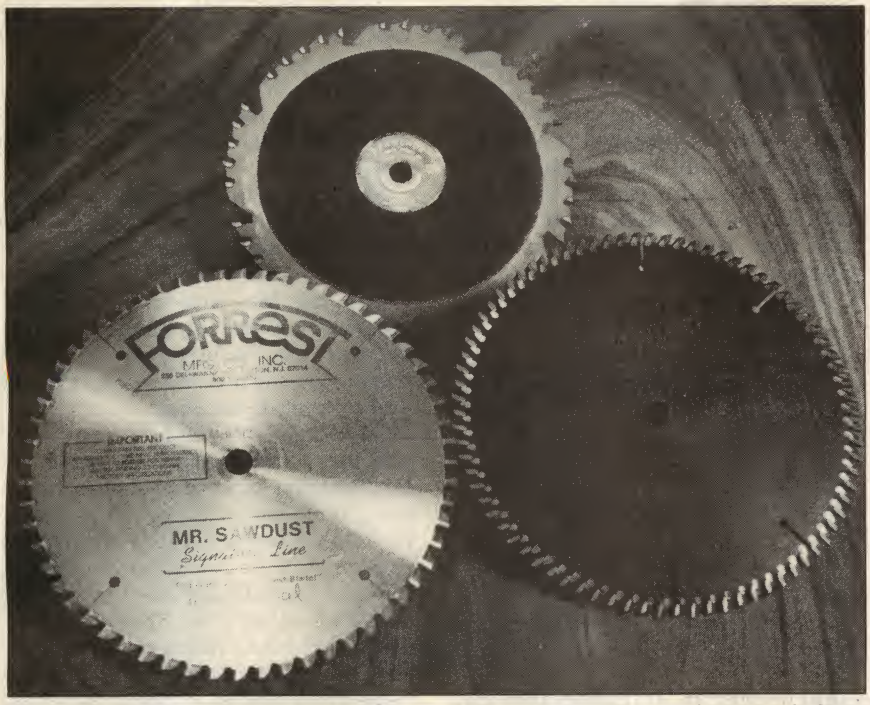
Now's the time to make your boating dream as real as a fast slalom ride over your boat's wake. Now's the time to make it a Merc.

DREAM MACHINE.



MERCURY OUTBOARDS

The possible dream.



Super blades: Sanblade (top), Mr. Sawdust (left), and Freud LU85M. All produce cuts so fine they require little or no follow-up smoothing. Right-hand photo shows results (top to bottom): Freud LU85M, Mr. Sawdust, and Sanblade.



Bottom two cuts were produced by Freud LU84M (combination blade) and Sears 72-tooth crosscut blade.

Super saw blades—which cuts smoothest?

The author tested three high-quality carbide-tipped saw blades and found that the trio produced cuts so fine they require little or no follow-up smoothing. The Sanblade gets its smoothness from coated abrasive discs that are bonded to its plate. The Mr. Sawdust and Freud blades rely on extremely tight tolerances in their manufacturing and on lots of teeth sharpened to perfection. Prices, though, are high: $79 to $162.

By A. J. HAND

Over the past several months, a real shouting match in print has been heating up between the makers of three new carbide-tipped blades. Excerpts:

"The one blade that does it all and does it better, longer, and quieter than any other blade" (Mr. Sawdust).

"Guaranteed to cut smoother than any blade you've ever owned or your money back" (Sanblade).

"It will give a much better finish than any other blade on the market" (Freud LU85M).

Which of these three new "super saw blades" really is the best? POPULAR SCIENCE asked me to find out. I put the three blades through their paces on a variety of hardwoods, softwoods, and plywoods. I made rips, crosscuts, and miters. I tried them on my radial-arm and table saws. Then I examined the cuts they produced.

The table summarizes how the blades rank in these tests and in tests of their quietness, overall "feel," and adaptability to use on the radial-arm saw.

But the table doesn't tell the whole story. First, the differences in cut quality between one blade and the others are very small, perhaps even insignificant. All three blades produce surfaces that require little, if any, follow-up smoothing. Ripped edges, for example, can be glued up with no need to plane or joint. A little light sanding will make any cut ready for finishing.

Each of these blades, however, has a unique design and "personality." And after using the blades for several weeks, I have concluded that it's the personality of the blade—the way it handles, feels, and sounds—that's more important than the slight differences in cut quality.

With that in mind, what follow are my observations on each blade:

Continued

Mr. Sawdust, in my opinion, is the most pleasant to use of the three blades tested. It runs the quietest and makes the smoothest cuts. When you feed it a piece of wood, it seems to slice rather than chew its way through the stock. Very low pressure is required to feed it; the blade seems eager to cut.

On a radial-arm saw, it has an almost magical feel. Again it is eager to cut, but it has no tendency to grab in the kerf. If you have ever used a radial-arm, you know one possible scenario: You carefully draw the saw into your stock, feeding it slowly. Suddenly the saw grabs and surges forward out of control. In a flash it binds up and stalls the motor, perhaps tearing your stock in the process. That won't happen with this blade. I ran it across some two-inch cherry, and it felt as though I was slicing salami. The Mr. Sawdust has one drawback, though: Its price is $162.

The Freud LU85M is a brand-new 80-tooth blade with a Teflon-coated plate. Designed strictly for crosscutting, it leads the group in that department, as the table shows. This blade is slightly behind the Mr. Sawdust in quietness, smoothness of feed, and overall feel. But it produced better or equal cut quality in four out of five categories. And like other Freud blades, this one is often available at discounts as high as 35 percent. That can bring its cost down to half that of a Mr. Sawdust.

Sanblade has a unique way of making smooth cuts: Bonded to each side of the blade are heavy-duty discs of 120-grit-coated abrasive that sand each cut as you make it. It's a good idea that loses something in actual practice.

Because the abrasive discs are only eight inches in diameter, they fall about an inch short of the rim of the blade. This means you have to raise the blade an inch above the top of your stock on a table saw. Increasing blade exposure increases your chances of an accident—and increases the odds that it will be a severe one.

Super saw blades: how they rate

	Freud LU85M	Mr. Sawdust	Sanblade
Crosscut cherry	1	1	1
Crosscut pine	1	2	3
Fir plywood	1	3	2
Rip pine	3	2	1
Rip cherry	2	2	1
Radial-arm rating	2	1	n.r.
Feel	2	1	3
Noise	2	1	3
Price ($)	110*	162	79

Notes: 1 is best, 3 is worst; n.r., not recommended; *available at discounts

To use the blade on a radial-arm saw, you have to bury the blade a full inch into your table, which is inconvenient and decreases the capacity of the blade. In effect, this is a 10-inch blade with the cutting capacity of an eight-incher.

The added friction produced by the sanding action of the Sanblade also makes it prone to grab and stall when used on a radial-arm. That two-inch cherry the Mr. Sawdust sliced with ease was virtually impossible to handle with the Sanblade. Every time I tried to ease it into the stock, it would grab and stall the saw.

Conclusions: If you have the money and use a radial-arm saw, make the Mr. Sawdust your first choice. If you use a table saw, the Freud is a better buy. And if you are interested in good performance at a real bargain price, consider the 50-tooth Freud combination blade called the LU84M. I've been using this blade in my shop for some time. It cuts nearly as smoothly as the three super blades—ripping and crosscutting plywood, hardwood, softwoods—and it sells for as little as $40. PS

THE SUPER BLADES: WHO MAKES THEM

Freud USA, Box 7178, 218 Field Ave., High Point NC 27264; **Forrest Mfg., Co.,** 250 Delawanna Ave., Clifton NJ 07014 (Mr. Sawdust); **The Clemson Group,** 22 Cottage St., Middletown NY 10940 (Sanblade).

Electronic tape measure

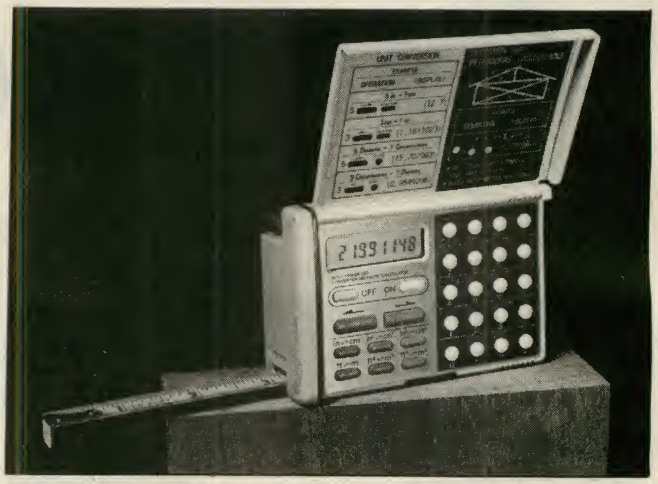
Not long after hand-held calculators came along, I forgot how to add, subtract, multiply, and divide. Now, thanks to the new Keson CalcuTape, I am going to forget the Pythagorean theorem and all those tedious formulas for converting the English system to metric and back.

Housed in a compact case measuring exactly 3.74 by 2.56 by 1.33 inches (that's 9.4996 by 6.5024 by 3.3782 centimeters) are pre-programmed electronics that will make all those calculations for you at the push of a few buttons. You can zip from Fahrenheit to Celsius, miles to kilometers, cubic inches to cubic centimeters, square feet to square meters, and so on, without a single worry over details such as "degrees F minus 32 times 5/9." Or is it 9/5?

All in all, CalcuTape can handle 32 different conversions, find the hypotenuse of any right triangle, and do squares, powers, reciprocals, plus basic arithmetic. And it has a memory, so you don't need yours.

On top of all this, there's a 16-foot measuring tape, calibrated in English and metric units, so it's easy to come up with data to plug into the calculator.

Using all this capability takes only a few seconds to master. All the button-pushing sequences are detailed inside the snap-open lid, and even the most complicated work requires just five separate button punches. After using the CalcuTape to help draw up plans for a cabinet I'm making, I am impressed.



CalcuTape combines a calculator with a 16-foot measuring tape. It makes English-to-metric conversions, finds any hypotenuse, and turns itself off after 12 minutes of nonuse. Calculation sequences are detailed inside the cover.

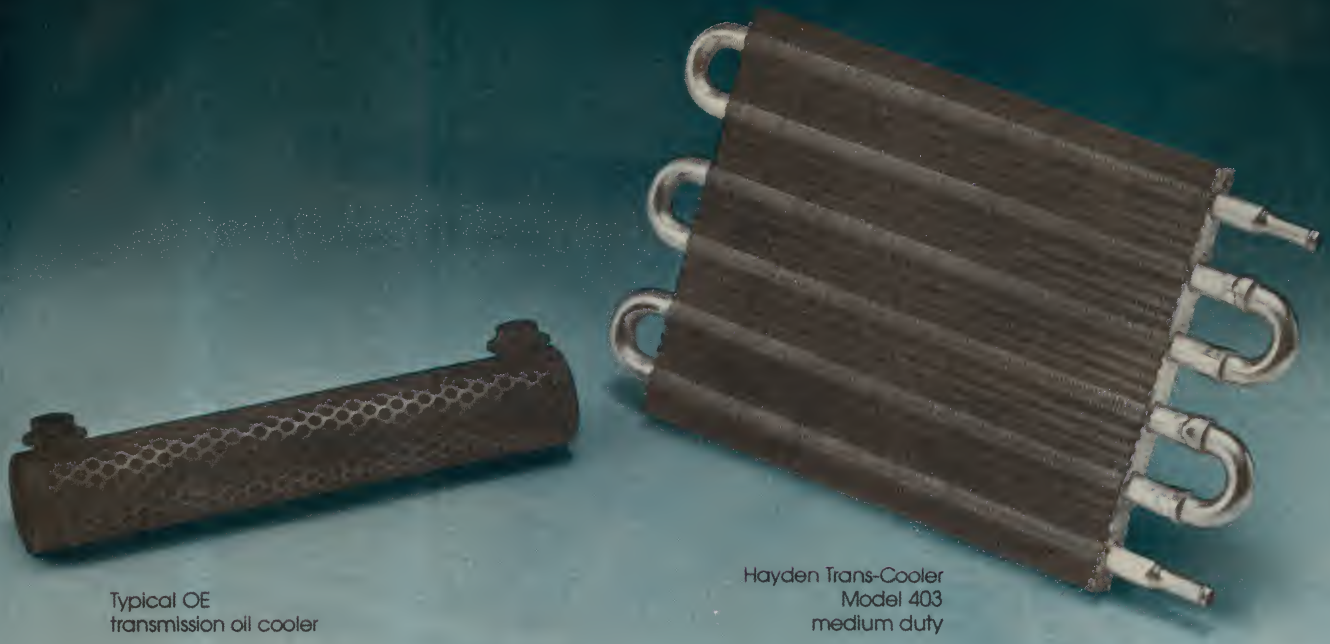
In fact, I have just two complaints:

I wish the tape were wider. A 16-foot tape should be an inch across for maximum stiffness at full extension. This one is just ⅝ inch wide.

And taking inside measurements is a bit clumsy. Instead of adding the usual two inches, the larger case of the CalcuTape makes you add 3¾ inches.

CalcuTape is made by Keson Industries (Box 394, Naperville, Ill. 60540), and it will probably be available at hardware stores and through Sears by the time you read this. What about price? It should cost approximately $60.—*A. J. Hand*

Over 13 million transmissions will fail in 1984.*



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Hayden Trans-Cooler
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More and more people are installing Hayden auxiliary Trans-Coolers on their cars. A mid-size Hayden Trans-Cooler can reduce your transmission's operating temperature as much as 70°F. Remember, each 20°F drop in temperature doubles oil and equipment life.

Quick do-it-yourself installation. If you can change the oil in your car, you can make the installation yourself using Hayden's patented Quik-Mount and Quick-Connect systems.

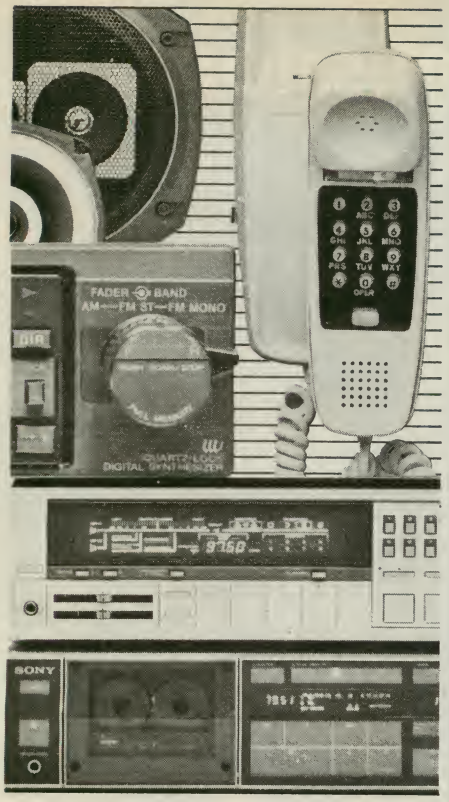
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*Courtesy ATRA (Automatic Transmission Rebuilders Association).

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Bits & Bytes

By JOHN FREE



Flip-up drives

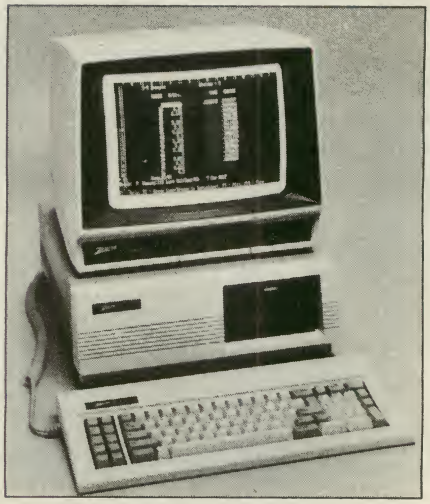
Zenith Radio Corp.'s computer division, Zenith Data Systems, has joined the stampede to make models partially compatible with the IBM PC. Zenith's add-ons to its popular S-100-bus-model line have been dubbed Z-100 PCs and include transportables such as the Z-160 (above) and desk-tops like the Z-150 (below). Zenith found that more than 175 IBM PC software titles and many plug-in boards were compatible. Some 6,000 Z-100 PCs will go into a new nationwide United Press International management system for radio broadcasters.

ZDS's 33-pound transportable has a unique, top-load flip-up disk system, available with one 5.25-inch 360K drive ($2,799) or two drives ($3,199). The Z-160 has a nine-inch amber CRT, with 640-by-200-pixel graphics. You can plug in a monitor for color. Zenith's PC portables and desk-tops have 128K of RAM, expandable to 640K. Standard serial and parallel ports support up to three peripheral devices. That's a bonus: On a fully configured Z-100 PC, the ports keep four slots for expansion boards free—an enhancement over IBM's machine. The desk-top models, which require a monitor, have similar features. The dual-drive desk-top is $3,099, and a floppy-disk-and-10.6-megabyte-Winchester model is $4,799.

Laser printers

While I was preparing an article about laser-based computer printers ["Quiet—High-Tech Printers at Work," PS, Feb.], a Canon official told me that low-priced models—at least for laser designs—were almost here. These printers deliver high-resolution output at high speed by forming characters or graphics with a solid-state laser on a sensitized drum. Canon's

Continued



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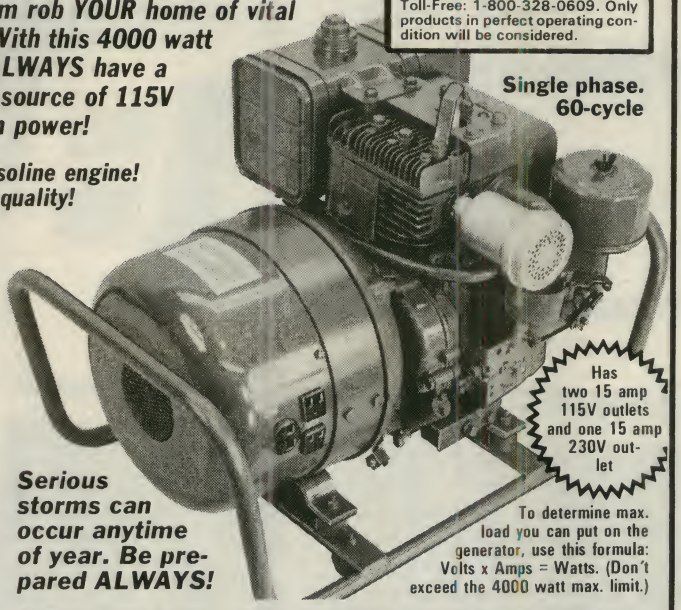
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Bits & Bytes

clever cost-cutting trick: combining the innards of its mass-produced, cartridge-type PC-10/20 copy machines ["Desk-Top Copier," PS, Aug. '83] with a laser system.

Canon's newest print mechanism, about the size of the PC-10/20s, can spew out eight pages a minute. Its 300-dot-per-inch resolution far exceeds impact dot-matrix models [PS, Dec. '83]. Canon (Lake Success, N.Y.) sells the mechanism to other firms (about $1,000 in volume), which add interface electronics. Completed printers, which can print 10 times faster than daisy-wheels, should soon be available for about $2,500 and up.

IBM's PC portable

Many portable-computer firms have made their hardware partially compatible with IBM PC software. But now Big Blue itself is entering the transportable field. IBM's $2,795 Portable Personal Computer is a 30-pounder that measures 20 by 17 by eight inches. There's plenty of memory: 256K, expandable to 512K. An optional drive doubles disk storage to 720K. The take-along PC has a nine-inch amber CRT.

Nibbles

- Like to feed single sheets, envelopes, or multi-copy forms through your low-cost tractor-feed printer? Paper Conveyor, from Valinco Automation Ltd. (2465 Dunwin Dr., Mississauga, Ontario, Canada), is a 3.5-foot-long plastic loop (three 84-line pages) with tractor-feed holes and slots to carry sheets. It costs $29.95.
- Timex has joined Texas Instruments and Mattel in escaping from the low-cost-home-computer field. Timex, which made the first under-$100 model for Sinclair Research [PS cover, Aug. '82], will stop making the Timex Sinclair 1500 and 2068 color computer when it uses up its parts inventory.
- Soundmaster II is a new $120 Apple II board that has dual sound-generation circuits and programs to create arcade-type sound effects. It's made by Kearsarge Industries Inc., 12310 Pinecrest Rd., Reston, Va. 22091.

$100,000 computer prize

Use your computer to make a mathematical breakthrough, and you may win the "Fredkin Prize for Computer Discovery in Mathematics," given by Carnegie-Mellon University. The prize is in numbers everybody can understand: $100,000. PS

Hot new shapes

[Continued from page 77]

ian company Rinaldo Piaggio, which will build the aircraft's wing, rear, and other components. Gates, a Tucson, Ariz., firm, will build the canard and forward fuselage.

The unusual co-production project came after Gates sought a new aircraft with Learjet performance and quality but costing less. Piaggio had the design, and the deal was struck.

"We were not interested in an under-performing airplane," said Gates vice-president Ronald D. Neal. "And we didn't want a 'me-too' airplane."

The GP-180 is the largest of its new breed, with a six-foot-wide cabin and five-foot, nine-inch interior height. "The Piaggio design was driven by the belief that the purpose of an aircraft is to fly people," Neal said. "We didn't want the wing's structural box protruding into the cabin where you end up stepping over it.

"But if you put the wing back there, the whole aircraft is out front and now what do you do?" Neal continued. "You can put a huge tail on it or you can put a canard up front to help provide the basic balance and stability."

Some composites will be used in the ship, Neal says, but the basic construction will be aluminum. "We feel comfortable with retaining aluminum for a period of time," said Neal. "A lot of proof is needed on composites. They're coming in a major way, but there is more to be done."

Tandem-wing jet

NASA's four-jet research aircraft, a modified A-3B Sky Warrior, is now in preliminary design and won't fly until 1988. A major goal of the program: to develop data on a canard's efficiency in keeping the plane's nose up as engine exhaust is blown over the main wing (see diagram).

"With a conventional tail, there would be a downward force vector, which reduces aircraft performance," NASA's Riddle said. "But by putting a canard and control surfaces out front, you get an upward force vector to balance out the nose-down moment. The name of the game is to get as much lift as you can so you can carry as much weight as possible."

Results from the NASA program are expected to influence both military- and commercial-jet design in the next decade, Riddle said.

Long before that, the four new high-performance business aircraft using canards and pusher engines will have opened a new age in business-aircraft design. "The industry has been conservative for years," said Neal. "Now we're pushing.

"These airplanes will be better than anything that exists today." PS

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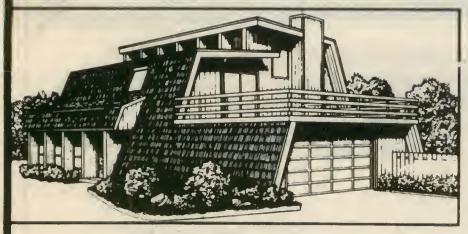
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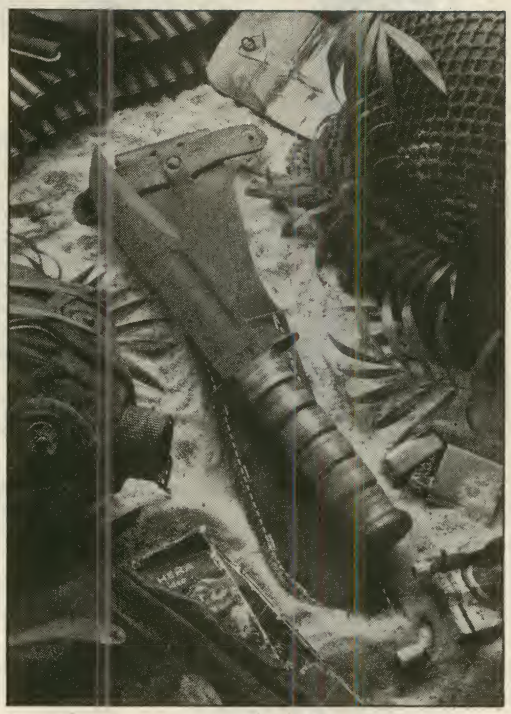
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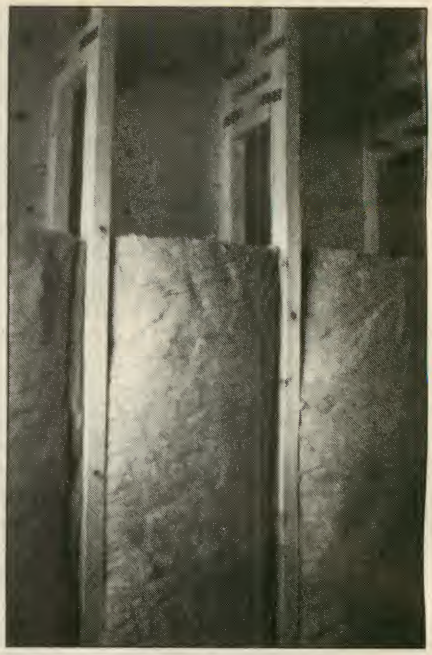
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Superinsulation wall system

Superinsulated houses are proven energy savers, but superinsulated walls —12 inches thick or more—can be costly, in both materials and labor.

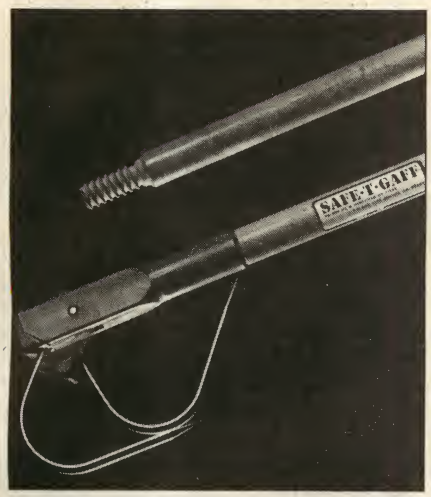
The solution? One came to engineer David Begin of Edmonton, Canada. He visualized a wall coming apart—2×4 wall studs splitting down the middle —leaving a space in between. In his mind's eye, too, came a way to hold the split wall together: 2×4 spacers at the top, middle, and bottom, secured with conventional truss plates. The result? The Ecostud truss stud.

An Ecostud truss stud typically has two 2×3s as the vertical components, but a 2×3 and a 2×4 member can be combined if extra strength is required. Ecostuds can be built by any plant that manufactures roof trusses, at a cost well under $1 per linear foot, Begin claims.

Generally, an Ecostud wall is built on the ground and then raised into position. Plumbing and wiring run between the vertical members. Once in place, the stud cavities are stuffed with R-40 fiberglass batts (strips of insulation, which, when packed into the gaps between horizontal spacers, minimize convection currents).

Another problem with superinsulated houses is also minimized by the Ecostud system. Thermal bridging —heat loss through contiguous wall members—is reduced by a factor of 10 over a conventional wall system. —*Paul Tatarewicz*

Safer gaff



Double-exposure photo (lower) shows Safe-T-Gaff in both positions—open for gaffing and closed for safe storage. Several handle sizes fit one gaff head.

We were 40 miles off Cape Hatteras when the large wahoo came up behind our boat and walloped a skipping bait fish. As Jerry ran to grab the rod from its holder, his leg smashed into an improperly stowed gaff and drove its point deep into his shin.

That was the first gaff accident I had ever seen, but according to Ted Simonson, inventor of the Safe-T-Gaff (shown above), 120,000 such accidents are reported every year. Simonson's gaff has a folding head that can be locked closed between uses, with its point safely out of the way. It locks open for action when you bring your fish to the boat.

I found the Safe-T-Gaff to be a good solution to the safety problem. The folding head is made of strong, high-quality Zytel plastic, and the mechanism locks firmly in both open and closed positions. The hook is made of stainless steel and comes with a needle-fine point.

Handles are solid maple with ribbed plastic grips. They have threads cut in one end so they can be screwed right into the plastic gaff head (photo). This makes the handles (which are sold separately) replaceable and interchangeable.

The Safe-T-Gaff is made in four models: A short billy gaff ($23.50) plus three-, four-, and six-footers, priced at $25.50, $27.50, and $34.95. All but the billy gaff will float. The gaffs have a lifetime guarantee on all moving parts; they're available at tackle shops or direct from Safe-T-Gaff (Box 312, West Hempstead, N.Y. 11552). If you order direct, add $2 for shipping.—*A. J. Hand*

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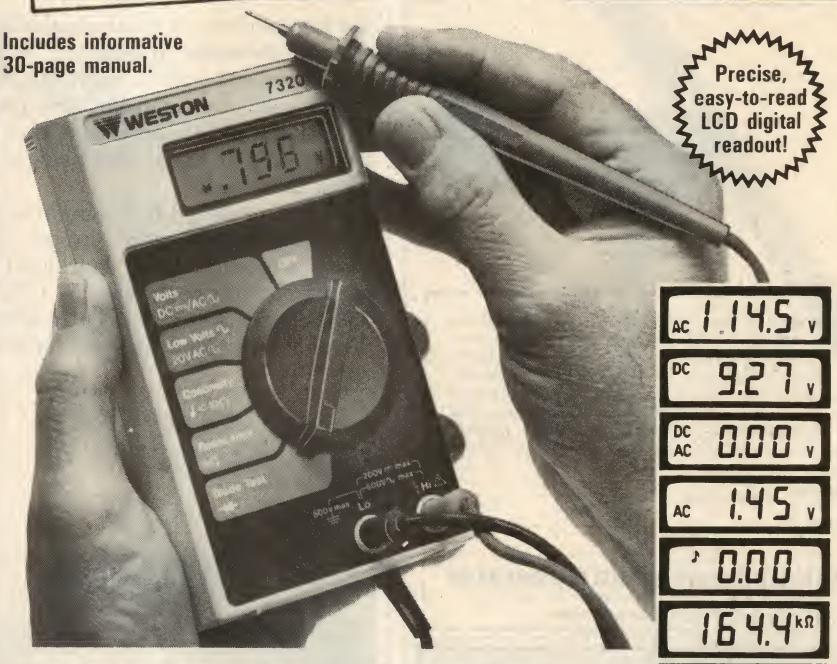
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Shop Talk

By AL LEES

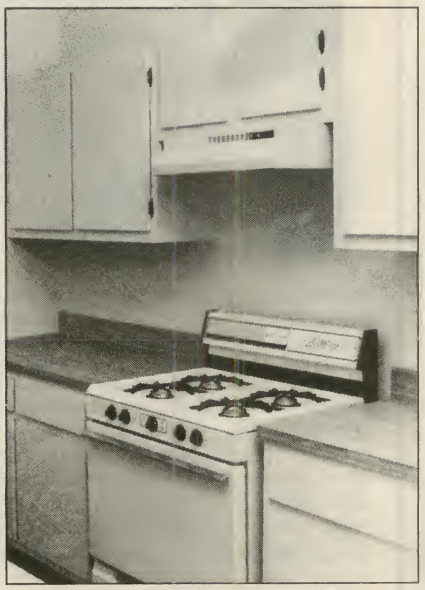
Installing a microwave

My kitchen was an ideal candidate for an over-the-stove microwave: It had the standard-width, high-mounted range hood shown in the first photo. Once I'd shut off the circuit that fed its fan and light, it was easy to remove this hood.

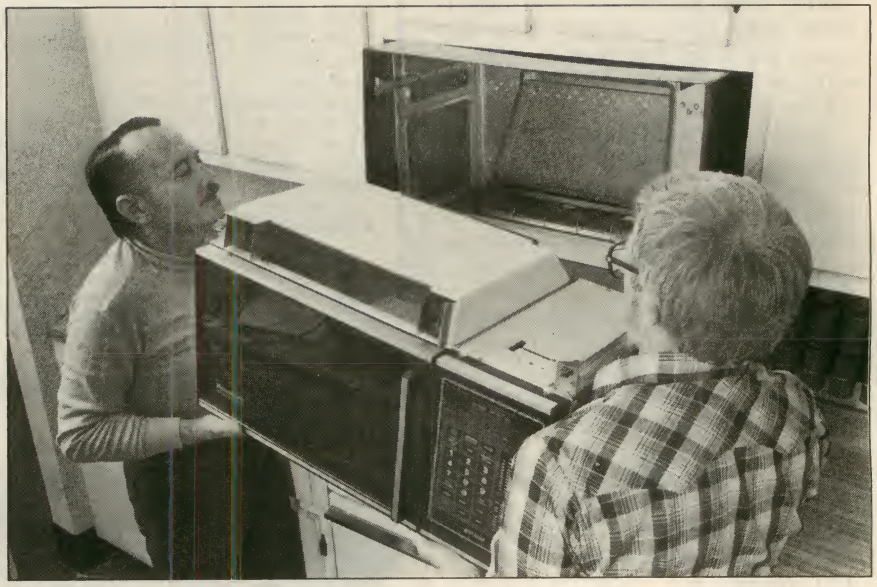
Unfortunately, I found my refrigerator was on the same circuit—and that's a no-no. When I ordered my oven from the Sears catalog (it's the $590 Spacemaster; Sears also offers a version with recipe memory for $740), I checked with the company's experts. They confirmed that it's best to put a microwave oven on its own grounded circuit.

If your existing circuit had a wall outlet, you'd just take care not to plug heavy-draw appliances into it while using the microwave. But since a fridge turns itself on and off and the Spacemaster draws at least as much current, if they both surged on at once my circuit-breaker would trip.

So I ran a new 110-volt, 15-amp line to an outlet box mounted inside the overhead cabinet and drilled a hole in







the bottom large enough to allow the three-prong plug on the end of the microwave's power cord to pass. Note in the second photo that I've separated the oven from its mounting sheath. (Charcoal filter, grille, and fluorescent tube, also removed, are on counter at right.) You feed the power cord up through the hole as you lift the sheath into position. Then you anchor the sheath with four bolts down through the cabinet floor and toggle bolts or lag screws through the rear wall. (Sears provides full-size drilling templates and all fasteners.)

Once the sheath is anchored, it's a simple (two-man) job to lift the oven onto the side tracks and slide it in. When you reconnect the wiring harness between the two, you're ready to program your first cooking job.



Plants on pulleys

Hanging plants dress up any add-on outdoor living area, whether deck or patio (and this issue offers plans for both). The problem is that overhead planters are hard to water without climbing on and off a step stool. The photo above demonstrates a system employed by the designer of this issue's tiled patio, but it can be adapted to any area with an overhead trellis or beam or where a steel cable can be run to a nearby tree.

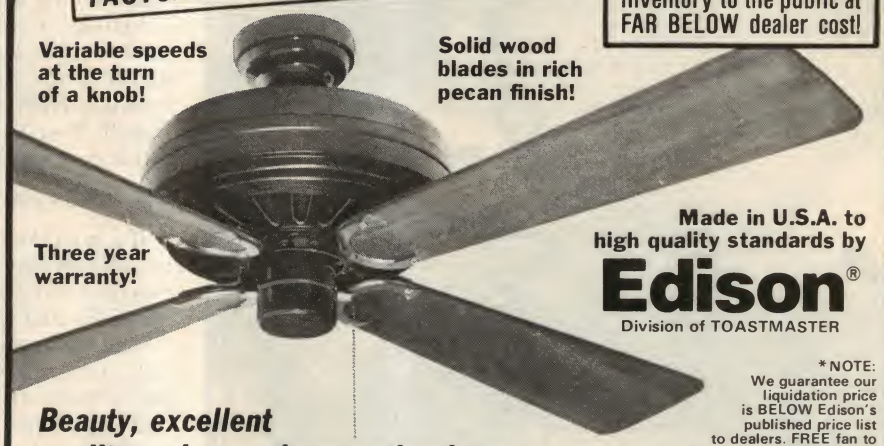
Planters are hung from steel rings at the end of a ¼-inch nylon rope that passes through a simple sheathed pulley designed for boat rigging. This pulley is anchored to the overhead beam or cable. The rope continues to a second pulley (mounted on the house at the same height) and down to a clevis screwed to the wall. In American Olean's photo, the man holds the plant at the best height for watering. He'll then hoist it back up and wrap his end of the rope around the clevis. PS

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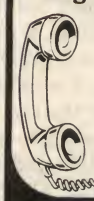
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This is a high quality fan, made to exacting specifications under strict U.S. quality control. The smooth running performance compares with the best on the market! The sturdy motor housing is in rich-looking chocolate brown. Antique brass blade brackets add accents of golden beauty! The dependable motor features all-metal construction with sealed, lubricated ball-bearings for smooth, quiet operation. And the motor is direct drive, with NO belts to wear out.

Overall vertical height is approx. 15". Convenient on/off pull chain. Pre-wired for easy installation of optional center light kit. (See order form for light kit.) Base is also pre-wired for easy installation. All hardware and instructions included. Supply of fans is very limited. Place your order promptly!

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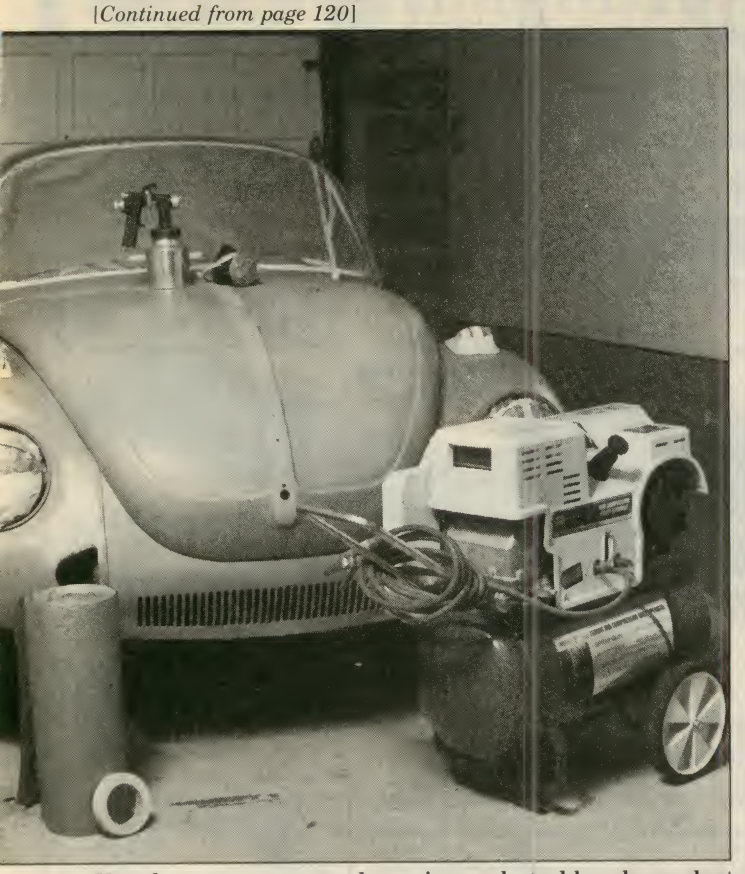


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Add this decorative four-light Florentine fixture to your fan. Elegant tulip-shape shades are crafted of frosted white glass and are complemented by antique brass fixtures. Uses 4 standard light bulbs (NOT incl.). A pull chain controls lights or fan or lights AND fan. Pre-wired for easy installation.
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[Continued from page 120]



Use the compressor and an air nozzle to blow loose dust or water drops out of crevices before the spray gun does. A roll of wide paper and fresh tape make masking easy.

Spray-painting safety

Talk about shop safety usually generates about as much enthusiasm as a long session with an insurance salesman. But if you intend to paint a car, at least a few words of caution are in order. First, because most automotive-type paint products are flammable, you should have a fire extinguisher handy in the work area. Second, wear a good respirator with replaceable filters. If you apply any paint removers, wear Viton or butyl-rubber gloves because the caustic chemicals in most removers will attack your skin. Wear safety glasses or goggles during any mixing, grinding, or power sanding. Finally, proper ventilation is extremely important. I propped a pair of old window fans in the open door and window of my garage.

want to check the vehicle-color code on the ID tag. This is usually located somewhere on the front of the car. My VW's was in the front trunk.

Acrylic lacquer offers some excellent advantages for beginners. It's less complicated to mix and spray, and it dries much more quickly than enamel. That means there's less chance for dust or suicidal bugs to settle into the finished paint. And if you make a mistake, you can sand or buff the problem away much sooner.

But there are some negative aspects about lacquer. It must be rubbed out to get the best-possible results. Rubbing out requires going over the entire car with ultra-fine sandpaper after the car has been painted. In addition, lacquers and some enamel paints don't get along. If you spray lacquer over an original enamel top coat, the lacquer may not adhere or will craze or bleed through the old layer of paint.

How can you tell what type of paint is on your car? Rub some lacquer thinner on the old surface. Lacquer paint will dissolve quickly and acrylic lacquer somewhat more slowly, but the lacquer thinner won't put a dent in alkyd or acrylic enamel.

Still, if you decide to paint over enamel with lacquer, you have a choice. You can take the car down to bare metal with a paint remover, or, if the enamel is in pretty good shape, you can use a primer-sealer. This will not only seal the possibly incompatible original paint from the new but will also act as a primer.

I chose an acrylic enamel for three reasons: It doesn't have to rubbed out like lacquer, it provides a tougher finish, and it covers with fewer coats (I shot three coats). Unfortunately enamel takes much longer to dry than lacquer. Result: Even with all my attention to shop cleanliness, my finish coat picked up some dust and a few minor sags.

Mistakes can be corrected

If a mistake occurs, don't panic. Even big problems can usually be cured without starting the entire job over. The two best ways to avoid mistakes are to read the directions carefully and then to take your time.

One of the most-common problems is a run or sag. Although beginners are usually guilty of applying too much paint, there are other, more-complicated reasons for runs and sags. When you mix your paint and thinner or reducer, make sure the proportions are correct. Although it would seem that too much thinner would be the only cause of runs, too little also will produce runs and sags. That's because the thinner is the evaporative agent in the paint and dries the application. This stabilizes the paint on the panel.

In addition, thinners and reducers are temperature specific. If you've selected a warm-weather thinner or reducer and the mercury drops, your paint will have a much greater tendency to run or sag. Be sure, too, that you're using the proper air pressure. Insufficient pressure won't properly atomize the paint. Beginners may also find themselves holding the spray gun too close. The best distance for most paints is the hand span from the tip of your pinky to the tip of your thumb.

If a sag appears, first try using a fine paintbrush to remove it. Then spray another coat over the brush marks. I let my small runs dry. You'd be surprised how well a 600-grit paper works with plenty of water, rubbing compound, and patience.

"Orange peel" is the second-most-common problem for painters. It looks like its name: The paint develops tiny pits instead of flowing smoothly over the surface. It's generally caused by using a cool-weather thinner or reducer on a hot day, improper mixing, too much air pressure, or holding the gun too far away. Orange peel is actually pretty easy to cure. If it isn't a serious case, apply a second, wetter coat over the problem area. If the problem doesn't appear until after the paint dries, you can still rub it out with wet 600-grit paper and rubbing compound.

Would I attempt the job again? Yes. I learned a lot from doing it myself. And I believe that even a beginner can do a competent job. You're not going to get the perfection of a baked-on, factory-applied finish or the mirror surface that a professional refinisher's dust-free paint booth can provide, but you can get darn close. Would I do anything different? I'd probably use a lacquer next time. The shorter drying time would make corrections quicker and easier. Even so, I'd be hesitant to try a major color change—especially from dark to light—because that requires multiple coats for even coverage. But simply renewing an existing finish is well within the skills of a determined do-it-yourselfer. PS



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If those other units do not have all these important features that DECIMATE 500C has than you should not buy them. Buy the best, Decimate 500C. This product should last for 10 years or more so why not get the best and the most powerful unit. And now, Decimate 500C also generates sound in the "infrasound" range. This is sound below humans and pets range of hearing that can be bothersome to even more pests than before.

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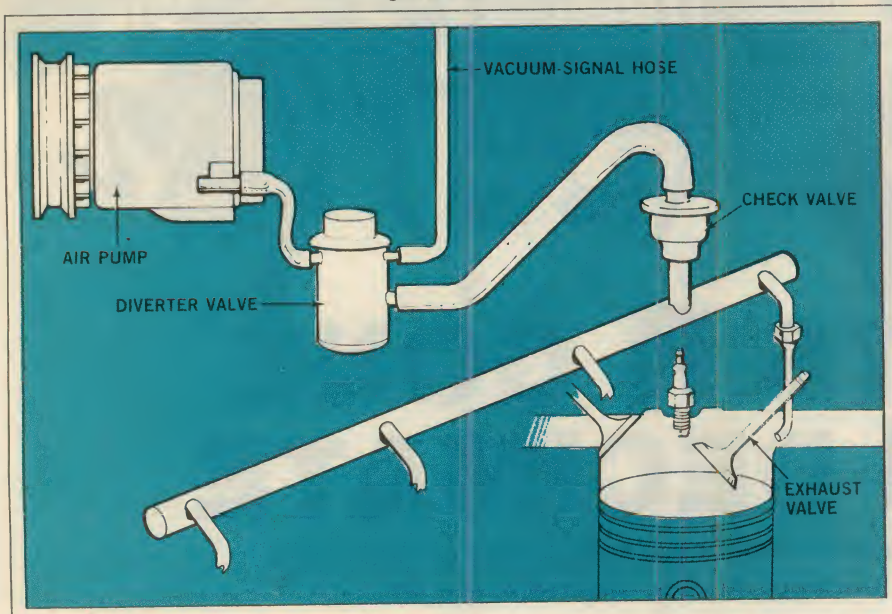
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Taking Care of Your Car

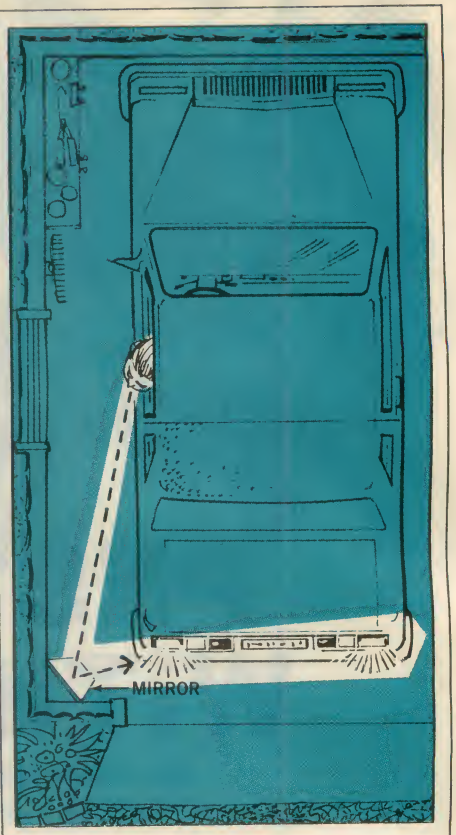
By STEVE MERCALDO

Got a useful car tip? Send it (with Social Security No.) to Car Care, POPULAR SCIENCE, 380 Madison Ave., New York, N.Y. 10017. We'll pay $50 if we use it. If two or more readers send the same tip, payment goes to the one with earliest postmark. No tips can be returned.



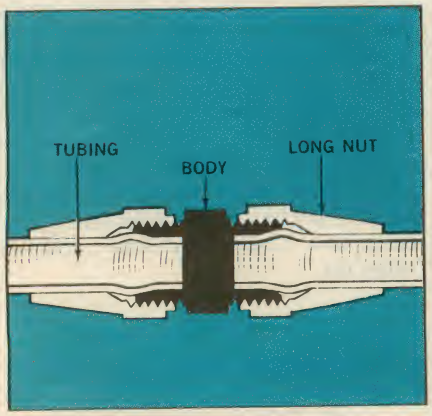
Trouble-shooting a backfire

If your car backfires during deceleration and the engine is equipped with an anti-pollution air pump, it's almost a sure sign that the pump's diverter valve isn't doing its job. There are two possibilities: The diverter valve's vacuum hose is leaking, or the valve is defective. To check the hose, fit a vacuum gauge in the line. At idle or off idle the gauge should read at least 15 inches. If it doesn't, check for an obstruction in the hose or in the fitting where it attaches to the engine. If, however, the gauge indicates a strong vacuum, chances are the diverter valve must be replaced.



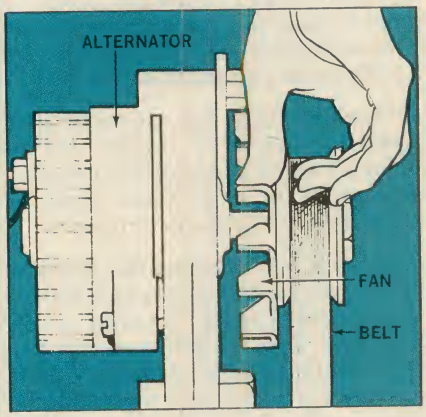
Mirror quick check

Install a mirror in the corner of your garage behind the driver's side of the car. Each time you back out, it's a snap to glance in the mirror for a quick check of your tail and brake lights. Not only are you safer on the road, but it could also save you from being stopped by the police.



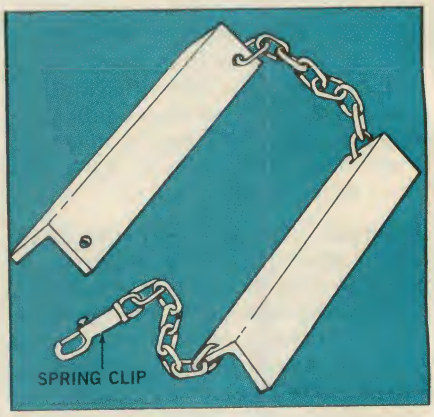
Tubing fix

Using neoprene hose and clamps to repair a broken transmission cooler line is not the best fix. In normal operation, the lines are subjected to vibration and twisting. Under these conditions, the neoprene will fatigue and can split open. Only a compression-type union fitting will properly support the lines at the connection.



Thumb test

A slipping alternator belt can cause a low charging rate. This will kill the battery. To check for a slipping belt, turn off the engine. Apply pressure with your thumb against one alternator fan blade. If the fan turns, the belt is slipping. First, check for a loose belt. If tension is correct, the belt is worn. The only fix is to replace it.



Safety wedges

Here's a good way of keeping your car from rolling off the jack: Use a pair of safety wedges. Make them by chaining together two 10-inch lengths of angle iron. Place the wedges around the tires that remain on the ground when the vehicle is lifted. A simple clasp makes it easy to position the wedges around the tire contact patch.

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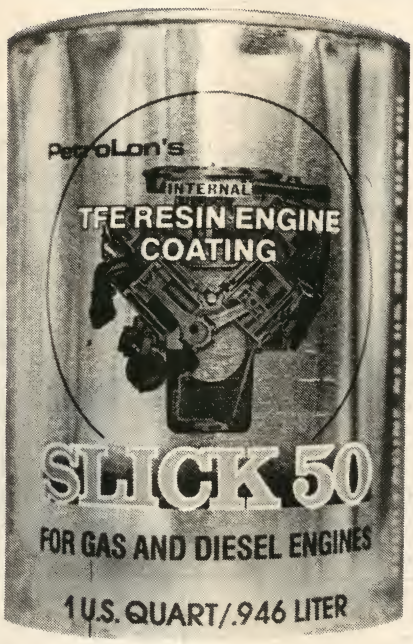
WHAT IS POLY? "Poly" is short for polytetrafluoroethylene (TFE). It is the slipperiest substance known to man **(1981 Guiness Book of World Records, p. 188).** The PetroLon Corporation, makers of Slick 50, has invented a way to permanently bind this slippery chemical to your engine with one treatment. All you do is add one quart of Slick 50 to your oil during oil and filter change. By reducing engine friction, Slick 50 increases gas mileage and horsepower and reduces engine operating temperature thus causing your oil and engine to last longer. Just as important, it reduces metal wear, defraying costly overhauls.

HOW DO I KNOW THIS ISN'T A FRAUD? Slick 50 has some very impressive credentials. The **"Consumers Digest"** magazine (March/April 1982, p. 35) states "Slick 50 does reduce engine heat and ordinary wear, and our informal tests indicate that it will improve gas mileage by about 2 to 3 miles per gallon. . . . Slick 50 does exactly what Petrolon claims it does." Researchers at the **Franklin Institute Research Laboratory**, after applying a powerful ultrasonic cleaning process to a Slick 50 treated engine part, were surprised at its permanence. They stated, "We actually expected the PetroLon Slick 50 TFE Resin coating to also be removed, but later found it was still there."

The **FAA (Federal Aviation Administration)** has fully accepted Slick 50 Aircraft Piston Engine Treatment (F.A.R. #33.49). An FAA test simulating 1400 hours of engine use (equivalent to about 70,000 miles on a car) showed almost zero engine wear!

Twenty-five hundred miles after removing Slick 50 from the crankcase, tests done at the **University of Utah Engineering Experiment Station** showed that the benefits of Slick 50 were still there. They reported a horsepower increase of 16.9% and 9.9% for light and heavy loading respectively. The senior engineering researcher at the **University of Southern California** in San Diego stated this, "Slick 50 does increase horsepower and decreases fuel consumption in tests done at the university." The **Space Shuttle Columbia** uses the chemical "poly" in its gears and bearings because it is the only chemical lubricant which can withstand the heat and corrosive elements of space.

Perhaps most dramatic of all is a torture-test overseen by the **Automotive Services Council for Pennsylvania** and shown on television station WTVE. Three cars with between 75,000 and 129,000 miles on them were treated with Slick 50. Six months later the oil was drained from each vehicle and the cars were driven without the oil plugs for about a half hour. The water temperature never rose and the engines sustained no apparent damage. **The Southwest Daily Times** (Dec. 19, 1982, p. 6), reports that a man from Liberal, Kansas, flew his airplane without oil for 30 minutes. There are many more tests available. If you are still skeptical, send $2.00 to defray printing and postage costs and we will send you additional, more detailed, test information, etc.



HOW DO YOU TREAT AN ENGINE? Very simply. A few minutes before oil and filter change, add engine flush (sent free with each order) to clean out your engine. Let your engine idle for 5 minutes. Then drain your oil, change filters and add the proper amount of oil less one quart. Add one quart Slick 50, drive for 30 minutes, and leave it in the crankcase for 3,000 miles. As the engine operates, the oil carries the polytetrafluoroethylene between the parts where it is burnished into the pores of the metal. Once impregnated it is permanent, so you do it only once, not each time you change oil. One quart of Slick 50 will treat all standard 4, 6 and 8 cylinder gasoline and diesel engines.

WILL IT WORK WITH MOST OIL? Yes, Slick 50 will work with all petroleum based oils and all synthetics that are compatable with petroleum based oils. An exception is graphite oils. However, once an engine is treated, you can go back to a graphite type if desired.

WHAT ARE THE BENEFITS OF SLICK 50? Your actual benefits in percentages may vary, depending on the kind of driving you do, vehicle condition, etc. By reducing friction, Slick 50 does all of the following: it increases gas mileage. It increases horsepower - - small economy cars and large RV's really need this. It makes for easier starting. It reduces operating temperatures, thus increasing the lubrication and life of your oil and your engine. Last, but not least, the drastic reduction in engine wear defrays or eliminates costly overhauls which can save you over $1,000.00. Slick 50 eliminates the "lubrication starvation" that all cars experience when first started before the oil has a chance to circulate. Up to 90% of the wear on a car can be caused by this lubrication starvation. You receive all of these benefits for less than the cost of two tanksfull of gas ($34.95).

WILL SLICK 50 HARM MY ENGINE OR AFFECT MY WARRANTY? No! Slick 50 is suspended in an excellent grade of petroleum oil which meets or exceeds every manufacturers engine warranty requirements. In addition, Slick 50 carries an API (American Petroleum Institute) service classification SF-CC-CD. It also carries the military specifications MIL-L-2104C and MIL-L-46152-A.

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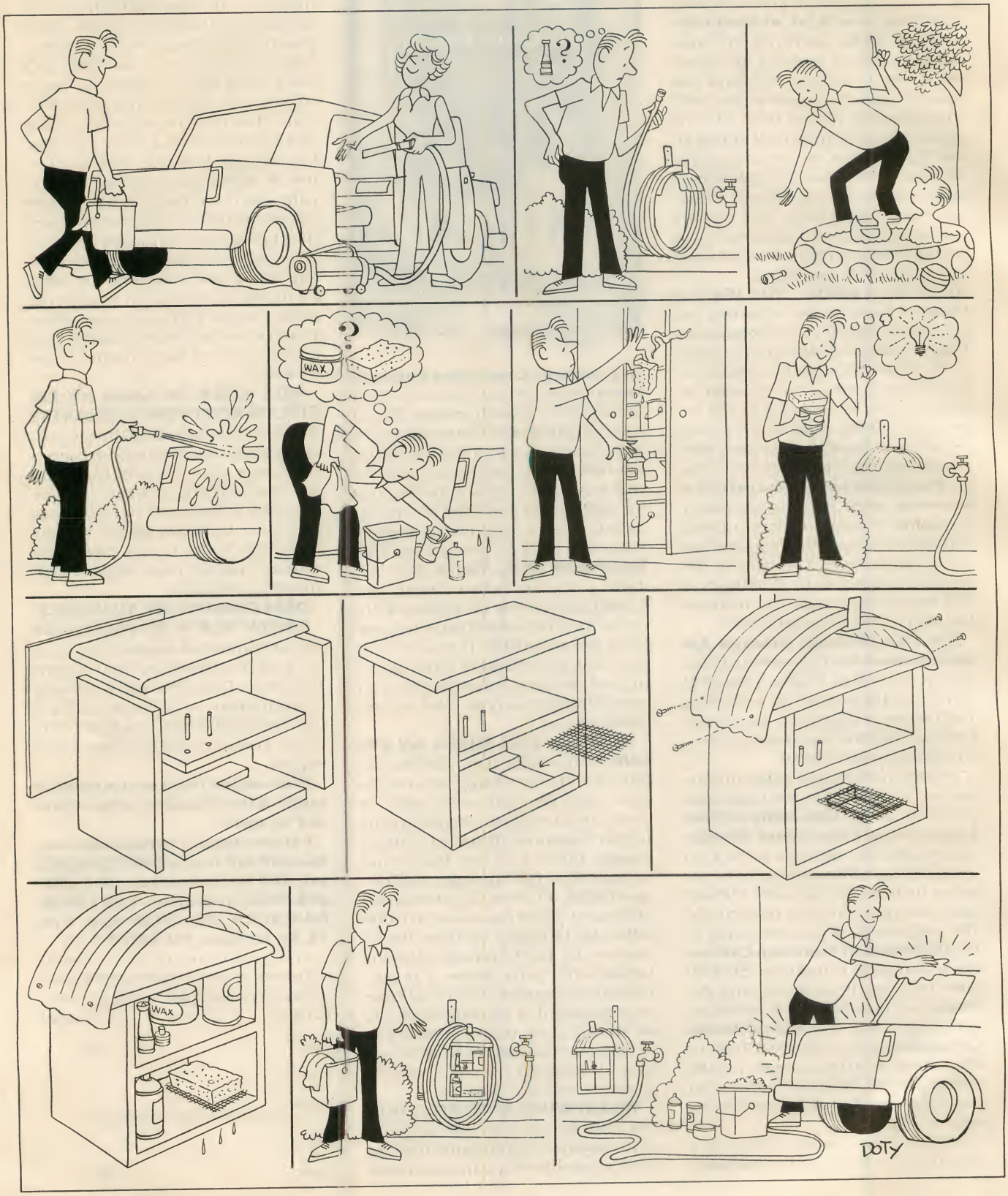
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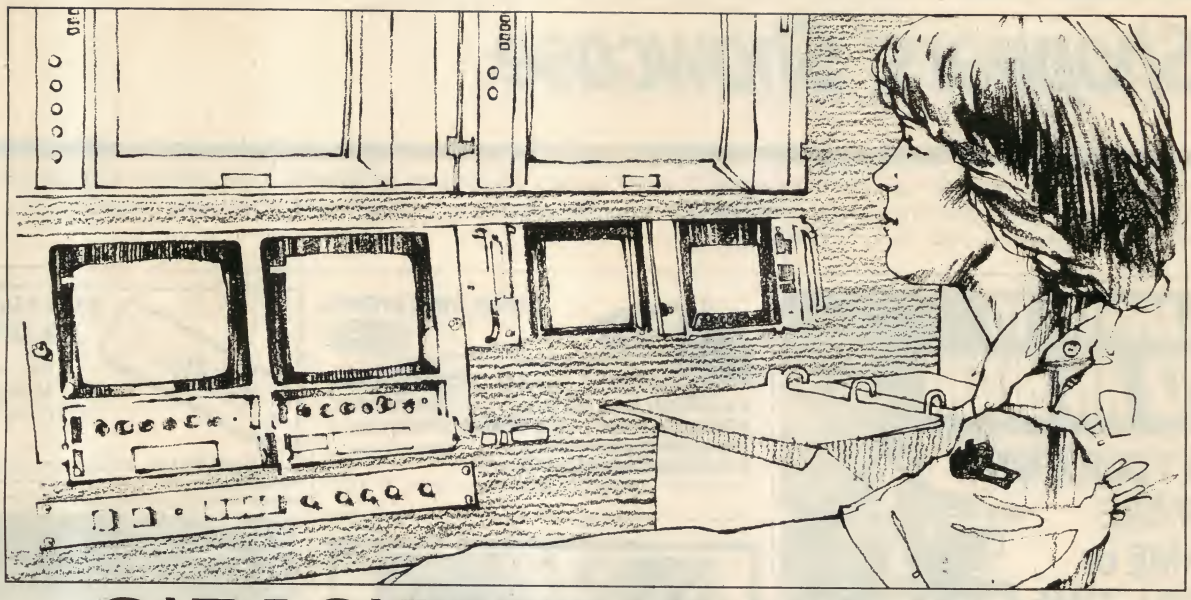
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By ROY DOTY

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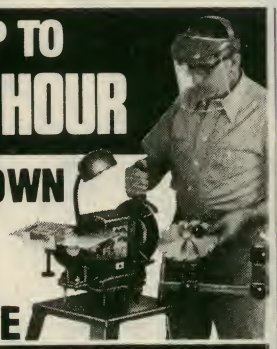
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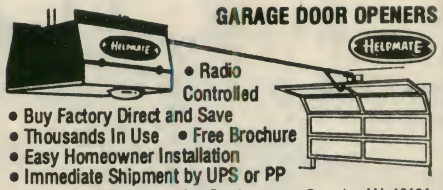
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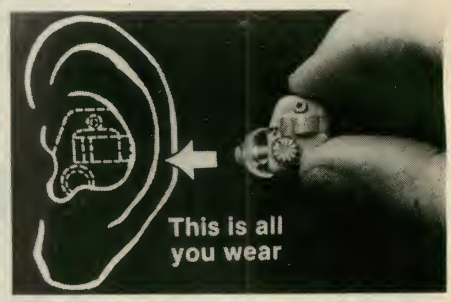


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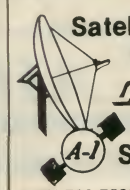
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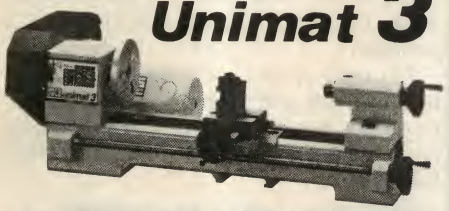
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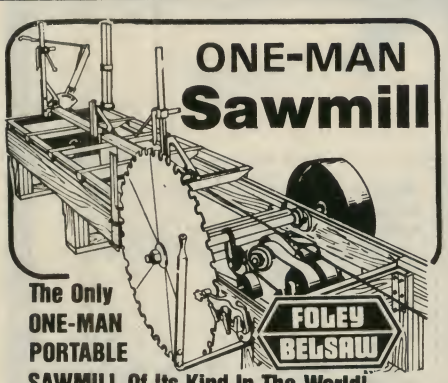
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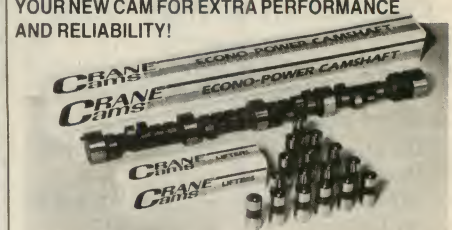
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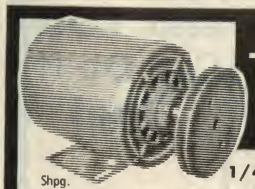
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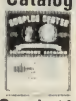
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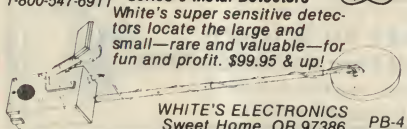
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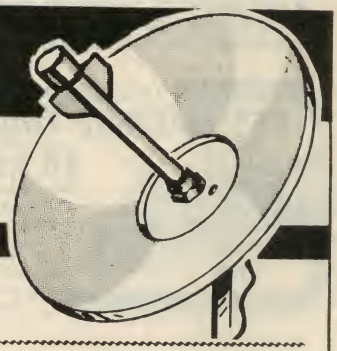
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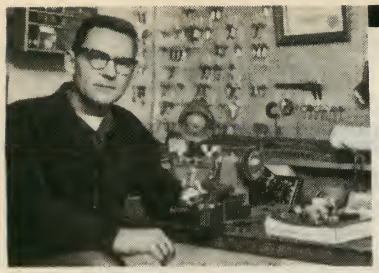
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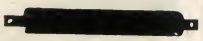
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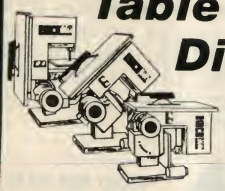
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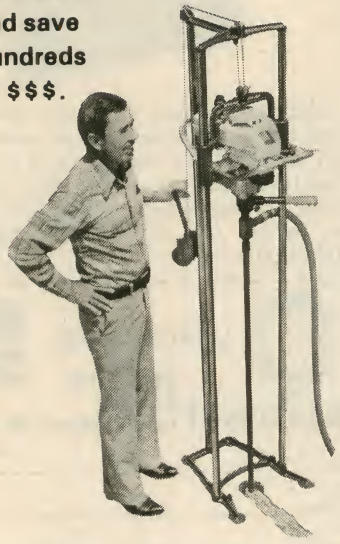
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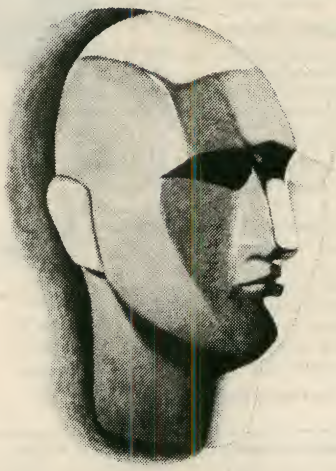
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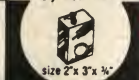
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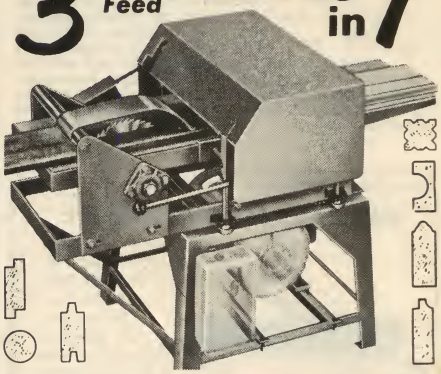
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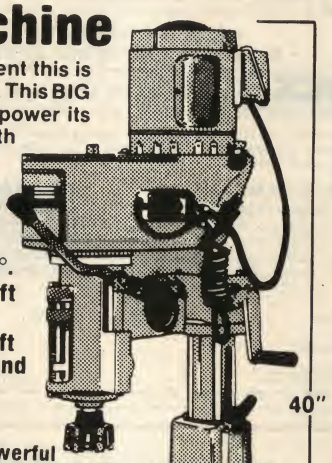
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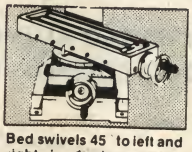




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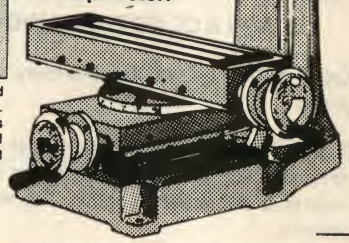


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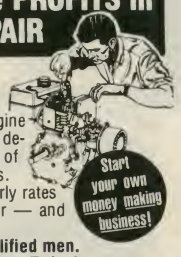
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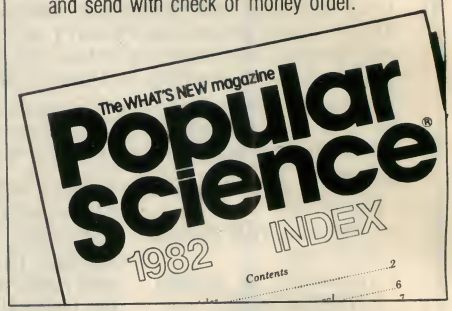
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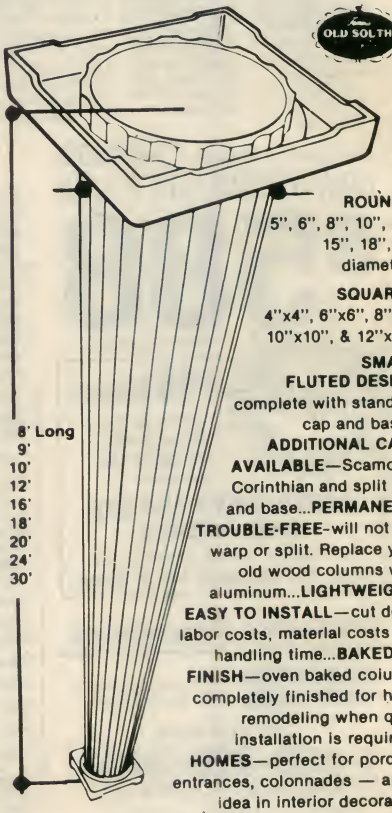
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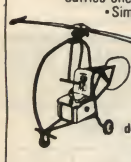
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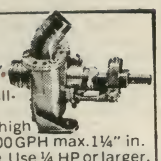
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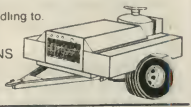


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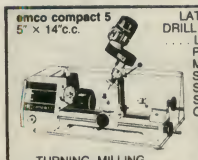
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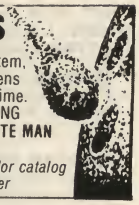
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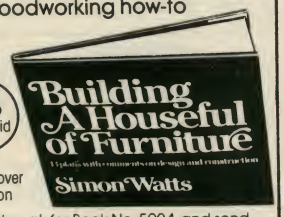
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